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Dive Distribution and Group Size Parameters for Marine Species Occurring in the U.S. Navy's Atlantic and Hawaii-Southern California Training and Testing Study Areas

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PREFACE

An important element of the Navy's comprehensive environmental planning is the acoustic effects analysis executed with the Navy Acoustic Effects Model (NAEMO) software. NAEMO was developed to estimate the possible impacts of anthropogenic sound on marine animals, combining established acoustic propagation modeling with data regarding the distribution and abundance of marine species. This report recommends species-typical static depth distributions and group size information for all marine mammal and sea turtle species that occur in the Atlantic Fleet Training and Testing (AFTT) and Hawaii – Southern California Training and Testing (HSTT) Study Areas that will be modeled using NAEMO.

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EXECUTIVE SUMMARY

An important element of the Navy's comprehensive environmental planning is the acoustic effects analysis executed with the Navy Acoustic Effects Model (NAEMO) software. NAEMO was developed to estimate the possible impacts of anthropogenic sound on marine animals, combining established acoustic propagation modeling with data regarding the distribution and abundance of marine species. This report recommends species-typical static depth distributions and group size information for all marine mammal and sea turtle species that occur in the Atlantic Fleet Training and Testing (AFTT) and Hawaii – Southern California Training and Testing (HSTT) Study Areas that will be modeled using NAEMO.

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LIST OF ABBREVIATIONS AND ACRONYMS

AFTT	Atlantic Fleet Training and Testing
DTAG	Digital Acoustic Recording Tag
HRC	Hawaii Range Complex
HSTT	Hawaii- Southern California Training and Testing
NAEMO	Navy Acoustic Effects Model
NUWC	Naval Undersea Warfare Center
SD	Standard Deviation
TDR	Time-Depth Recorder
U.S.	United States

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1. INTRODUCTION

The United States (U.S.) Navy is required to assess potential impacts of Navy-generated sound in the water on protected marine species in compliance with applicable laws and regulations, including the National Environmental Policy Act, Executive Order 12114, the Marine Mammal Protection Act, and the Endangered Species Act. This report describes the methods and analytical approach to quantifying the depth distributions in the water column and group sizes of marine mammals and sea turtles to be used within the Navy Acoustic Effects Model (NAEMO).

1.1 The Navy Acoustic Effects Model

NAEMO is the standard model used by the Navy to estimate potential impacts to marine species from impulsive and non-impulsive sound sources used during Navy training and testing activities. NAEMO combines marine species distribution information with environmental parameters, propagation characteristics, sound source parameters, and typical training or testing scenarios in order to assess the level of behavioral disturbance, hearing impacts (including both temporary and permanent threshold shifts), and other injuries predicted for individual marine mammals and sea turtles likely to be in the vicinity of Navy training and testing activities.

1.2 Data Inputs

NAEMO first uses location-specific density (more detailed information regarding species density is available in density technical reports by U.S. Department of the Navy (In Prep.-b, In Prep.-c) and group size information to patchily distribute a given marine species into a simulation area. The depth distribution data are then used to place animals in the water column at the depths at which they are typically found. An animal is reassigned a new depth every four minutes throughout the simulation based on the depth distribution for that species. Where available, seasonal or geographically-specific depth and group size information is used.

Density data are not available for all taxa of concern for Navy activities (Section 2). In addition to available marine mammal and sea turtle data, specific information about environmental conditions and projected Navy activities within a study area is needed to run NAEMO and quantify potential impacts to marine mammals and sea turtles. These environmental data include information about bathymetry, seafloor composition (e.g., rock, sand), and factors that vary throughout the year such as wind speed and sound velocity profiles. The details of Navy training and testing activities are also collected, including location, frequency, and source characteristics. For more detailed information about the NAEMO model, consult the Quantitative Analysis Technical Report (U.S. Department of the Navy In Prep.-a).

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2. Marine Mammal and Sea Turtle Depth Distributions

The best available science from literature reviews was used to obtain species-specific depth distribution information for the Atlantic Fleet Training and Testing (AFTT) and Hawaii-Southern California Training and Testing (HSTT) Study Areas (Figure 2-1). Journal articles, books, technical reports, cruise reports, funding agency reports, theses, dissertations, and raw data from individual researchers were assessed for this report.

As described in Section 1.1, depth distribution data are combined with species density data during the NAEMO modeling process. Densities were obtained from the Navy Marine Species Density Database (U.S. Department of the Navy In Prep.-b, In Prep.-c). In some instances, density data were provided for guilds of species, rather than for individual species (e.g., pilot whales, *Kogia* spp., AFTT and HSTT beaked whales, AFTT seals, HSTT sea turtles, and AFTT hardshell sea turtles are all groups of two or more species). These multi-species guilds were created because observers could not differentiate closely related species at sea, or because the sample sizes of the species observed individually were too small to incorporate into density modeling. For these cases, a single representative species was chosen or a composite depth distribution was created to correspond to the multi-species groupings contained in the density data.

The information required for representing a species in NAEMO specifically focuses on the percent of time each animal spends in the water column, defined here as a range of depths extending from the surface to the maximum dive depth of each species. Percentage values may be slightly above or below 100 percent, due to decimal rounding, especially when animals spend smaller percentages of time close to their maximum dive depth. Rather than round down to zero, the deep bins are often rounded up in order to show a fraction of a percentage when it has been recorded that a species is capable of reaching that depth bin. For pinniped species, time spent hauled out of the water is not represented (this is accounted for in the density data). Depth distributions contain percent time spent in the water only, either at the surface or in given depth bins.

2.1 Surrogate Species and Study Areas

Depth distribution data within this report are based upon species-specific tagging data obtained during literature review. If tagging data were not available for a particular species, data for the most similar species were used in the form of a surrogate. A species will generally only be considered a surrogate for modeling if the species is closely related (within the same genus or family), feeds on similar prey, or has a distribution in similar water types (e.g., continental shelf waters). The exception to the general surrogate selection is the two species of *Kogia* spp. (dwarf and pygmy sperm whales), for which there are no other species in their family to choose as surrogates. Therefore, a species from another family within their suborder (Odontoceti) was chosen as a surrogate. Surrogate species (if required) for all species are provided in Table 2-1 for both AFTT and HSTT Study Areas.

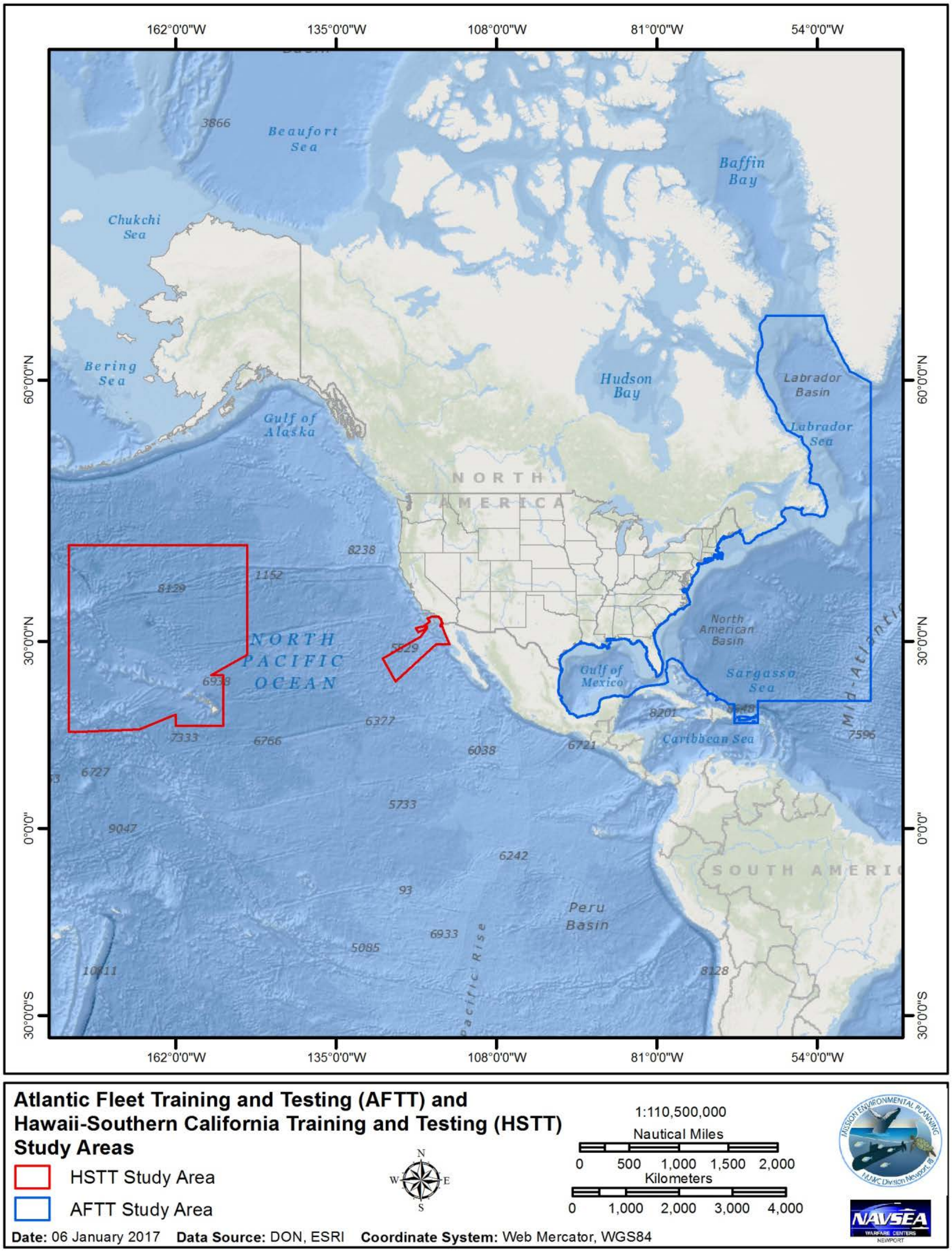

Figure 2-1. Atlantic Fleet and Hawaii-Southern California Training and Testing Study Areas

Table 2-1. Marine Mammal and Sea Turtle Species Occurring in the Atlantic Fleet Training and Testing (AFTT) and Hawaii-Southern California Training and Testing (HSTT) Study Areas. Potential presence is indicated with an X

Species Name	Common Name	Surrogate species	AFTT	HSTT		Section
				Southern California portion of the HSTT Study Area	Hawaii Range Complex	
Cetaceans						
Family Balaenidae						
Eubalaena glacialis	North Atlantic right whale	N/A	X	-	-	2.2.1.1.2
Family Balaenopteridae						
Balaenoptera acutorostrata	Common minke whale	N/A	X	X	X	2.2.1.2.1
Balaenoptera borealis	Sei whale	Bryde's whale (*Balaenoptera edeni*)	X	X	X	2.2.1.2.6
Balaenoptera edeni	Bryde's whale	N/A	X	X	X	2.2.1.2.5
Balaenoptera musculus	Blue whale	N/A	X	X	X	2.2.1.2.2
Balaenoptera physalus	Fin whale	N/A	X	X	X	2.2.1.2.3
Megaptera novaeangliae	Humpback whale	N/A	X	X	X	2.2.1.2.4
Family Delphinidae						
Delphinus capensis	Long-beaked common dolphin	Pantropical spotted dolphin (*Stenella attenuata*)	-	X	-	2.2.1.3.14, 2.2.1.2.13
Delphinus delphis	Short-beaked common dolphin	Pantropical spotted dolphin (*Stenella attenuata*)	X	X	-	2.2.1.3.15
Feresa attenuata	Pygmy killer whale	Risso's dolphin (*Grampus griseus*)	X	X	X	2.2.1.3.10
Globicephala macrorhynchus	Short-finned pilot whale	N/A	Modeled as *Globicephala* spp.	X	X	2.2.1.3.5

Table 2-1. Marine Mammal and Sea Turtle Species Occurring in the Atlantic Fleet Training and Testing (AFTT) and Hawaii-Southern California Training and Testing (HSTT) Study Areas. Potential presence is indicated with an X (Cont'd)

Species Name	Common Name	Surrogate species	AFTT	HSTT: Southern California portion of the HSTT Study Area	HSTT: Hawaii Range Complex	Section
Cetaceans						
Globicephala melas	Long-finned pilot whale	N/A	Modeled as *Globicephala* spp.	-	-	2.2.1.3.6
Globicephala spp.	Pilot whales (long-finned and short-finned pilot whales)	Short-finned pilot whale (*Globicephala macrorhynchus*)	X	-	-	2.2.1.3.7
Grampus griseus	Risso's dolphin	N/A	X	X	X	2.2.1.3.9
Lagenodelphis hosei	Fraser's dolphin	Short-finned pilot whale (*Globicephala macrorhynchus*)	X	-	X	2.2.1.3.8
Lagenorhynchus acutus	Atlantic white-sided dolphin	Pantropical spotted dolphin (*Stenella attenuata*)	X	-	-	2.2.1.3.16
Lagenorhynchus albirostris	White-beaked dolphin	Pantropical spotted dolphin (*Stenella attenuata*)	X	-	-	2.2.1.3.17
Lagenorhynchus obliquidens	Pacific white-sided dolphin	Pantropical spotted dolphin (*Stenella attenuata*)	-	X	-	2.2.1.3.18
Lissodelphis borealis	Northern right whale dolphin	Pantropical spotted dolphin (*Stenella attenuata*)	-	X	-	2.2.1.3.19
Orcinus orca	Killer whale	N/A	X	X	X	2.2.1.3.1
Peponocephala electra	Melon-headed whale	Risso's dolphin (*Grampus griseus*)	X	-	X	2.2.1.3.11

Table 2-1. Marine Mammal and Sea Turtle Species Occurring in the Atlantic Fleet Training and Testing (AFTT) and Hawaii-Southern California Training and Testing (HSTT) Study Areas. Potential presence is indicated with an X (Cont'd)

Species Name	Common Name	Surrogate species	AFTT	HSTT		Section
				Southern California portion of the HSTT Study Area	Hawaii Range Complex	
Cetaceans						
Pseudorca crassidens	False killer whale	Risso's dolphin (*Grampus griseus*)	X	-	X	2.2.1.3.12
Stenella attenuata	Pantropical spotted dolphin	N/A	X	-	X	2.2.1.3.13
Stenella clymene	Clymene dolphin	Pantropical spotted dolphin (*Stenella attenuata)*	X	-	-	2.2.1.3.20
Stenella coeruleoalba	Striped dolphin	Pantropical spotted dolphin (*Stenella attenuata*)	X	X	X	2.2.1.3.20
Stenella frontalis	Atlantic spotted dolphin	N/A	X	-	-	2.2.1.3.2
Stenella longirostris	Spinner dolphin	Pantropical spotted dolphin (*Stenella attenuata*)	X	-	X	2.2.1.3.21
Steno bredanensis	Rough-toothed dolphin	N/A	X	-	X	2.2.1.3.3
Tursiops truncatus	Common bottlenose dolphin	N/A	X	X	X	2.2.1.3.4
Family Eschrichtiidae						
Eschrichtius robustus	Gray whale	N/A	-	X	-	2.2.1.4.1
Family Kogiidae						
Kogia breviceps	Pygmy sperm whale	Short-finned pilot whale (*Globicephala macrorhynchus*)	Modeled as *Kogia* spp. guild	Modeled as *Kogia* spp. guild	X	2.2.1.5.1
Kogia sima	Dwarf sperm whale	Short-finned pilot whale (*Globicephala macrorhynchus*)	Modeled as *Kogia* spp. guild	Modeled as *Kogia* spp. guild	X	2.2.1.5.2

Table 2-1. Marine Mammal and Sea Turtle Species Occurring in the Atlantic Fleet Training and Testing (AFTT) and Hawaii-Southern California Training and Testing (HSTT) Study Areas. Potential presence is indicated with an X (Cont'd)

Species Name	Common Name	Surrogate species	AFTT	HSTT: Southern California portion of the HSTT Study Area	HSTT: Hawaii Range Complex	Section
Cetaceans						
Kogia spp. (*Kogia breviceps* and *Kogia sima)*	*Kogia* spp.	Short-finned pilot whale (*Globicephala macrorhynchus*)	X	X	-	2.2.1.5.3
Family Phocoenidae						
Phocoena phocoena	Harbor porpoise	N/A	X	-	-	2.2.1.6.1
Phocoenoides dalli	Dall's porpoise	N/A	-	X	-	2.2.1.6.1
Family Physeteridae						
Physeter macrocephalus	Sperm whale	N/A	X	X	X	2.2.1.8.1
Family Ziphiidae						
Berardius bairdii	Baird's beaked whale	Cuvier's beaked whale (*Ziphius cavirostris*)	-	X	-	2.2.1.9.6
Hyperoodon ampullatus	Northern bottlenose whale	Cuvier's beaked whale (*Ziphius cavirostris*)	X	-	-	2.2.1.9.7
Indopacetus pacificus	Longman's beaked whale	Blainville's beaked whale (*Mesoplodon densirostris*)	-	-	X	2.2.1.9.2
Mesoplodon densirostris	Blainville's beaked whale	N/A	-	Modeled as HSTT beaked whale guild	X	2.2.1.9.1
Ziphius cavirostris	Cuvier's beaked whale	N/A	-	X	X	2.2.1.9.5

Table 2-1. Marine Mammal and Sea Turtle Species Occurring in the Atlantic Fleet Training and Testing (AFTT) and Hawaii-Southern California Training and Testing (HSTT) Study Areas. Potential presence is indicated with an X (Cont'd)

Species Name	Common Name	Surrogate species	AFTT	HSTT: Southern California portion of the HSTT Study Area	HSTT: Hawaii Range Complex	Section
Cetaceans						
Mesoplodon spp. (*M. densirostris, M. ginkgodens, M. stejnegeri, M. carlhubbsi, M. perrini, M. peruvianis*)	HSTT beaked whale guild (Blainville's beaked whale, ginkgo-toothed beaked whale, Stejneger's beaked whale, Hubb's beaked whale, Perrin's beaked whale, and pygmy beaked whale)	Blainville's beaked whale (*Mesoplodon densirostris*)	-	-	X	2.2.1.9.3
Ziphius cavirostris, Mesoplodon densirostris, M. bidens, M. europaeus, M. mirus	AFTT beaked whale guild (Cuvier's beaked whale, Blainville's beaked whale, Sowerby's beaked whale, Gervais' beaked whale, and True's beaked whale)	Blainville's beaked whale (*Mesoplodon densirostris*)	X	-	-	2.2.1.9.4

Table 2-1. Marine Mammal and Sea Turtle Species Occurring in the Atlantic Fleet Training and Testing (AFTT) and Hawaii-Southern California Training and Testing (HSTT) Study Areas. Potential presence is indicated with an X (Cont'd)

Species Name	Common Name	Surrogate species	AFTT	HSTT		Section
				Southern California portion of the HSTT Study Area	Hawaii Range Complex	
Carnivores						
Family Otariidae						
Arctocephalus townsendi	Guadalupe fur seal	N/A	-	X	-	2.2.2.1.1
Callorhinus ursinus	Northern fur seal	N/A	-	X	-	2.2.2.1.2
Zalophus californianus	California sea lion	N/A	-	X	-	2.2.2.1.3
Family Phocidae						
Cystophora cristata	Hooded seal	N/A	X	-	-	2.2.2.2.1
Halichoerus grypus	Grey seal	N/A	Modeled as AFTT seal guild	-	-	2.2.2.2.4
Monachus schauinslandi	Hawaiian monk seal	N/A	-	-	X	2.2.2.2.2
Mirounga angustirostris	Northern elephant seal	N/A	-	X	-	2.2.2.2.3
Pagophilus groenlandicus	Harp seal	N/A	X	-	-	2.2.2.2.7
Phoca vitulina	Harbor seal	N/A	Modeled as AFTT seal guild	X	-	2.2.2.2.5
Pusa hispida	Ringed seal	N/A	X	-	-	2.2.2.2.8
Halichoerus grypus, Phoca vitulina	AFTT Seal guild (harbor seal and grey seal)	Composite of grey seal and harbor seal	X	-	-	2.2.2.2.6
Sirenians						
Family Trichechidae						
Trichechus manatus	West Indian manatee	N/A	X	-	-	2.2.3.1.1

Table 2-1. Marine Mammal and Sea Turtle Species Occurring in the Atlantic Fleet Training and Testing (AFTT) and Hawaii-Southern California Training and Testing (HSTT) Study Areas. Potential presence is indicated with an X (Cont'd)

Species Name	Common Name	Surrogate species	AFTT	HSTT: Southern California portion of the HSTT Study Area	HSTT: Hawaii Range Complex	Section
Sea Turtles						
Family Dermochelyidae						
Dermochelys coriacea	Leatherback sea turtle	N/A	X	-	Modeled as HSTT sea turtle guild	2.2.4.1.1
Family Cheloniidae						
Chelonia mydas	Green sea turtle	N/A	Modeled as AFTT hardshell sea turtle guild	X	Modeled as HSTT sea turtle guild	2.2.4.2.1
Eretmochelys imbricata	Hawksbill sea turtle	N/A	Modeled as AFTT hardshell sea turtle guild	-	Modeled as HSTT sea turtle guild	2.2.4.2.5
Caretta caretta	Loggerhead sea turtle	N/A	X	-	Modeled as HSTT sea turtle guild	2.2.4.2.6
Lepidochelys kempii	Kemp's ridley sea turtle	Green sea turtle (*Chelonia mydas*)	X	-	-	2.2.4.2.2
Lepidochelys olivacea	Olive ridley sea turtle	N/A	Modeled as AFTT hardshell sea turtle guild	-	Modeled as HSTT sea turtle guild	2.2.4.2.3
Chelonia mydas, Lepidochelys olivacea, Eretmochelys imbricata	AFTT hardshell sea turtle guild (green, olive ridley, hawksbill)	Composite of all unidentified sightings of all hardshell turtle species	X	-	-	2.2.4.2.4

Table 2-1. Marine Mammal and Sea Turtle Species Occurring in the Atlantic Fleet Training and Testing (AFTT) and Hawaii-Southern California Training and Testing (HSTT) Study Areas. Potential presence is indicated with an X (Cont'd)

Species Name	Common Name	Surrogate species	AFTT	HSTT		Section
				Southern California portion of the HSTT Study Area	Hawaii Range Complex	
Chelonia mydas, Eretmochelys imbricata, Caretta caretta, Lepidochelys olivacea, Dermochelys coriacea	HSTT sea turtle guild (green, hawksbill, loggerhead, olive ridley, leatherback)	Composite of green, hawksbill, olive ridley, loggerhead, and leatherback sea turtles	-	-	X	2.2.4.2.7

2.2 Marine Mammal and Sea Turtle Dive Behavior Summaries

This section discusses the depth distributions that were constructed for each species or surrogate species based on the best available science. Ideally, depth distributions would be specific to different locations; however, sometimes diving data were not available for the precise locations within AFTT and HSTT. Marine mammal and sea turtle dive behaviors are not easily stereotyped, but a species' behavior can generally be quantified by using an average percentage of time that an animal will typically spend within a range of depths, or depth bin. For each species, a distribution throughout the water column is presented, along with a list of the references that are the source of the data and an explanation about how these references were used to create the distribution. Depth bins are given in meters (m). Depending on the species, the distribution may cover a larger or smaller range of depths, such as for a shallow diving fur seal or a deep diving sperm whale. Likewise, depth bins may be smaller near the surface or larger at greater depths (e.g., 20 m bins near the surface where the animal spends more time or 100 m bins at the deepest depths the animal can reach). For certain species (e.g., North Atlantic right whale, humpback whale, and sperm whale), more than one depth distribution is given due to documented seasonal or geographic differences in diving behavior. Individual species are listed within each order.

2.2.1 Cetaceans

2.2.1.1 Family Balaenidae

2.2.1.1.1 *Eubalaena glacialis*, North Atlantic Right Whale

North Atlantic right whales migrate between their feeding grounds in temperate and sub-polar shelf waters and near-shore waters, and their breeding grounds in sub-tropical near-shore waters (Kenney 2002). Their prey consist entirely of zooplankton, particularly large copepods. Right whales are skim feeders that swim

open-mouthed, both at the surface and at depth, through patches of congregated prey (Kenney 2002; Kenney et al. 2001; Mate and Nieukirk 1992).

Due to a separation of behaviors based on location within a foraging ground or within a breeding ground, two separate representative depth distributions were compiled for North Atlantic right whales. Foraging grounds include all waters off the North American seaboard that are north of Cape Hatteras, North Carolina. In order to build a representative depth distribution for the North Atlantic right whale on foraging grounds, depth distributions for 46 whales from the Bay of Fundy were provided by D. Nowacek and A. McGregor (2010). The Bay of Fundy data reflect skim feeding both at the surface and at depth (Nowacek and McGregor 2010). Parks et al. (2011) examined dive behavior during the spring feeding season in Cape Cod Bay (Parks et al. 2011). Parks et al. (2011) reported whales spent on average 84 percent of time within 3 m of the surface, while Nowacek and McGregor (2010) reported whales spent on average 32.89 percent of time in the top 10 m. The average of these percentages amounts to 58.45 percent of the whales' time spent in the surface bin (0-10 m). The remaining depth bins provided by Nowacek and McGregor (2010) were redistributed proportionally to account for the remaining 41.56 percent of time. The resulting depth distribution for right whales on foraging grounds is given in Table 2-2. This distribution is consistent with maximum dive depths reported in the literature of 174 m (Baumgartner and Mate 2003) and 272 m (Mate and Nieukirk 1992).

Table 2-2. Percentage of Time at Depth for the North Atlantic Right Whale on Foraging Grounds[1]

Depth Bin (m)	% of Time at Depth	Depth Bin (m)	% of Time at Depth
0–10	58.45	110–120	5.19
10–20	2.39	120–130	4.79
20–30	1.66	130–140	3.88
30–40	1.22	140–150	3.31
40–50	2.08	150–160	1.94
50–60	1.07	160–170	0.84
60–70	0.97	170–180	0.28
70–80	2.29	180–190	0.02
80–90	2.33	190–200	0.02
90–100	2.62	200–210	0.01
100–110	4.65	210–220	0.01

[1]Based on data from Nowacek and McGregor (2010) and Parks et al. (2011)

In order to build a representative depth distribution for North Atlantic right whales on breeding grounds, depth distributions for six whales in the South Atlantic Bight were provided by Nowacek and McGregor (2010) (Table 2-3). The South Atlantic Bight encompasses the continental shelf from Cape Hatteras, North Carolina south to Cape Canaveral, Florida. The depth distribution in table 2-3 will also be used for both migration periods and any other movements to the south of Cape Hatteras.

Table 2-3. Percentage of Time at Depth for the North Atlantic Right Whale on Breeding Grounds[1]

Depth Bin (m)	% of Time at Depth
0–4	46.05
4–8	29.16
8–12	9.73
12–16	14.76

Table 2-3. Percentage of Time at Depth for the North Atlantic Right Whale on Breeding Grounds[1] (Cont'd)

Depth Bin (m)	% of Time at Depth
16–24	0.31

[1] Based on data from Nowacek and McGregor (2010)

2.2.1.2 Family Balaenopteridae

2.2.1.2.1 *Balaenoptera acutorostrata*, Common Minke Whale

Minke whales are widely distributed throughout the world oceans, occurring in coastal and continental shelf waters, the deeper waters along continental slopes, and further seaward (Dorsey et al. 1990; Øien 1990). Fish (e.g., capelin, sandlance, and herring) and planktonic crustaceans (e.g., krill) are the main components of the minke whale diet (Haug et al. 1995). Minke whales feed by side-lunging into schools of prey as well as gulping large amounts of water (Jefferson et al. 2008).

Little data have been collected on the dive behavior of minke whales. In order to build a representative depth distribution for minke whales, data from Figure 2 in Blix and Folkow (1995) were used. Blix and Folkow (1995) presented a time-depth record for a single minke whale tagged off the west coast of Svalbard, a Norwegian archipelago. This animal was predominantly foraging between 25 and 50 m. Two depth bins and the time spent within each depth bin were estimated, with the resulting depth distribution shown. The depth distribution data are derived from a short (75 minutes [min]) dive profile of a single animal, in which two behaviors are represented, cruising (52 percent of time) and foraging (48 percent of time), however, the amount of time spent in these two behaviors can vary significantly among individuals (Blix and Folkow 1995). The depth distribution for common minke whales is given in Table 2-4.

Table 2-4. Percentage of Time at Depth for the Minke Whale[1]

Depth Bin (m)	% of Time at Depth
0–25	79.7
25–65	20.3

[1]Based on data from Blix and Folkow (1995)

More recent data suggest that the common minke whale is capable of diving to greater depths than depicted by this distribution. For example, minke whales in the Antarctic have been associated with krill patches found at a median depth of 118 m (Friedlaender et al. 2009b). Off Scotland, minke whales are found where patches of pre-spawning herring occur at depths between 100 and 150 m (MacLeod et al. 2003b), while off the coast of California, tagged minke whales dove to 130 m (Southall et al. 2014), although in both cases whales spend the majority of time in the top 25 m of the water column. There is also limited evidence that minke whales may exhibit diurnal variation in diving behavior (Joyce et al. 1990; Stockin et al. 2001). The depth distribution shown in Table 2-4 will be considered representative for common minke whales until more information becomes available.

2.2.1.2.2 *Balaenoptera musculus*, Blue Whale

Blue whales have a cosmopolitan distribution, living in both coastal and offshore waters (Jefferson et al. 2008). Blue whales track the diel vertical migration of their prey and feed almost exclusively on euphausiids,

or krill (Sears 2002). Although surface feeding has been observed during the daylight, it is more usual for blue whales to dive to at least 100 m into layers of euphausiid concentrations during daylight hours and feed nearer the surface at night (Sears and Perrin 2008).

In order to build a representative depth distribution for blue whales, data from Figures 4 and 8 in Oleson et al. (2007), as well as Figure 2 from Acevedo-Gutiérrez et al. (2002) were used. Oleson et al. (2007) provided graphs of the percent time at depth of 38 blue whales off the coast of California in Figure 8. The data for the non-vocal, AB callers, and D callers were averaged together to get a general depth distribution. However, percentage of time at the surface was ignored by this study. By incorporating the average number of surfacing events over time in the sample dive profile from Figure 4 in Oleson et al. (2007) and the average time spent at surfacing events from Figure 2 in the Acevedo-Gutiérrez et al. (2002) study, a percent time spent in the surface bin could be estimated (20.9 percent). The remaining bins from the Oleson et al. (2007) study were redistributed proportionally to account for the remaining 79.1 percent of time. The depth distribution for blue whales is given in Table 2-5.

Table 2-5. Percentage of Time at Depth for the Blue Whale[1]

Depth Bin (m)	% of Time at Depth	Depth Bin (m)	% of Time at Depth
0–5	20.9	155–165	2.21
5–15	12.74	165–175	2.37
15–25	9.89	175–185	2.21
25–35	6.41	185–195	2.29
35–45	5.30	195–205	1.42
45–55	3.96	205–215	1.11
55–65	3.48	215–225	1.11
65–75	2.77	225–235	1.03
75–85	2.21	235–245	0.87
85–95	2.37	245–255	0.71
95–105	2.45	255–265	0.71
105–115	2.06	265–275	0.32
115–125	1.98	275–285	0.24
125–135	2.06	285–295	0.16
135–145	2.14	295–305	0.16
145–155	2.29	305–315	0.16

[1]Based on data from Oleson et al. (2007) and Acevedo-Gutiérrez et al. (2002)

While other studies did not include depth distributions for blue whales, they did provide additional information to categorize dive behavior. Blue whales in the Gulf of St. Lawrence conducted foraging dives to 150 m, where feeding lunges were observed (Doniol-Valcroze et al. 2011). Similarly, a study conducted in Monterrey Bay found that blue whales fed on the most concentrated patches of krill at depths of 130 to 150 m (Schoenherr 1991). Blue whales off central California foraged at depths between 130 and 300 m (Calambokidis et al. 2008; Croll et al. 2001), while in southern California, dive depths ranged from 50 to 350 m (Acevedo-Gutiérrez et al. 2002; Croll et al. 2001; De Vos et al. 2012; Goldbogen et al. 2012; Goldbogen et al. 2013; Mate et al. 2016; Oleson et al. 2007; Southall et al. 2014). Seven whales tagged off the coast of Southern California dove to a mean depth of 140 m and a maximum depth of 204 m during foraging, while to only a mean depth of 67.6 m during non-foraging dives (Croll et al. 2001). These data are consistent with the depth distribution in Table 2-5.

2.2.1.2.3 *Balaenoptera physalus*, Fin Whale

The fin whale occurs in greatest concentrations in cold and temperate waters around the globe, and are commonly found seaward of the continental slope (Aguilar 2002). Prey species include euphausiids (Laidre et al. 2010; Ruchonnet et al. 2006; Vikingsson 1997), schooling fish such as herring and capelin (Nottestad et al. 2002), and cephalopods (Flinn et al. 2002). A 2001 study has shown that dense prey concentrations are typically found at depths greater than 100 m off the coast of California (Croll et al. 2001).

In order to build a representative depth distribution for fin whales, data from Figure 4a in Croll et al. (2001) and the text of Goldbogen et al. (2006) were used. Due to the lack of data on time spent at depth, the data from Croll et al. (2001) will be used as a proxy for percentage of time spent at depth. Croll et al. (2001) found that, amongst the 15 tagged fin whales, there was a maximum dive depth of 316 m. Foraging dives were deeper and longer in duration than non-feeding dives. Goldbogen et al. (2006) reported that tagged whales spent 40 percent of time in the top 50 m. Time spent at depths below 50 m were extracted from dive profiles presented in Croll et al. (2001) to represent the remaining 60 percent of time. The depth distribution for fin whales is given in Table 2-6.

Table 2-6. Percentage of Time Spent at Depth for the Fin Whale[1]

Depth Bin (m)	% of Time at Depth
0–50	40
50–70	13.9
70–90	9.6
90–110	8.14
110–130	11.43
130–150	8.41
150–170	3.48
170–190	2.01
190–210	1.37
210–230	0.55
230–250	0.64
250–270	0.18
270–290	0.09
290–310	0.18

[1]Based on data from Croll et al. (2001) and Goldbogen et al. (2006)

While other studies did not include depth distributions for fin whales, they did provide additional information to categorize dive behavior. Off southern California foraging dives of 100 to 300 m (Acevedo-Gutiérrez et al. 2002; Goldbogen et al. 2006; Mate et al. 2016) have been recorded. In the Ligurian Sea, a maximum dive to over 470 m was noted (Panigada et al. 1999), while Southall et al. (2014) reported that dives by fin whales rarely exceeded 250 m. These data are consistent with the depth distribution in Table 2-6.

2.2.1.2.4 *Megaptera novaeangliae*, Humpback Whale

Humpback whales have a cosmopolitan distribution in the coastal and continental shelf waters of the globe. They migrate between mid- to high-latitude foraging grounds and low-latitude breeding grounds (Clapham 2002). Humpback whales feed on a variety of organisms, including euphausiids and small schooling fish (Hain et al. 1982; Hazen et al. 2009; Laerm et al. 1997).

Due to a separation of behaviors based on location within a foraging ground or within a breeding ground, two separate representative depth distributions were compiled for humpback whales. In order to build a representative depth distribution for humpback whales on foraging grounds, data from Figure 3.8 as well as the text of Dietz et al. (2002) were used. Dietz et al. (2002) shows the number of dives per hour to specific depth bins. The data from Dietz et al. (2002) will be used as a proxy for percentage of time spent at depth for the six whales tagged off the foraging grounds of West Greenland. While Figure 3.8 begins at a depth of 8 m, the text states that the average time spent at the surface is 83.3 percent during mid-day and 75 percent at midnight, resulting in an average surface time of 79.2 percent. The data from Dietz et al. (2002) were then redistributed proportionally to account for the remaining 20.8 percent of time. The depth distribution for humpback whales on foraging grounds is given in Table 2-7.

Table 2-7. Percentage of Time at Depth for Humpback Whales on Foraging Grounds[1]

Depth Bin (m)	% of Time at Depth
0–8	79.2
8–20	11.65
20–35	2.70
35–50	1.04
50–100	1.56
100–150	1.56
150–200	1.25
200–300	1.25
300–400	0.21

[1]Based on data from Dietz et al. (2002)

Dive depths on the Greenland foraging grounds are consistent with the depth of feeding reported by Goldbogen et al. (2008) off central California and Dolphin (1987b) off Alaska. Dolphin (1987a), however, reported that 75 percent of feeding dives were to less than 60 m, and Friedlaender et al. (2009a) found evidence of bottom feeding in the shallower water (less than 50 m) of the Gulf of Maine. While the depth distribution in Table 2-7 has a maximum depth of 400 m, over 95 percent of the time is in the top 50 m. Therefore, the depth distribution in table 2-7 is consistent with these studies as well.

Humpback whales have major breeding grounds in several locations, including the West Indies, Hawaii, Mexico, and Japan (Clapham 2002). In order to build a representative depth distribution for humpback whales on breeding grounds, data from Table 3 in Baird et al. (2000) were used. Baird et al. (2000) reported the time at depth data for 10 whales in Hawaiian waters. While all 10 whales were thought to be males, the whales were engaged in a variety of behaviors, including escorting females and calves. Therefore, the depth distribution in Table 2-8 represents the best estimate of time spent at depth by whales on a breeding ground. Baird et al (2000) found that, on average, about 40 percent of a whale's time was spent in the top 10 m and about 90 percent of the time was spent in the top 100 m. The depth distribution for humpback whales on breeding grounds is given in Table 2-8.

Table 2-8. Percentage of Time at Depth for the Humpback Whale on Breeding Grounds[1]

Depth Bin (m)	% of Time at Depth	Depth Bin (m)	% of Time at Depth
0–10	39.55	90–100	1.55
10–20	26.51	100–110	1.39
20–30	11.65	110–120	1.31

Table 2-8. Percentage of Time at Depth for the Humpback Whale on Breeding Grounds[1] (Cont'd)

Depth Bin (m)	% of Time at Depth	Depth Bin (m)	% of Time at Depth
30–40	4.25	120–130	0.92
40–50	3.04	130–140	0.72
50–60	2.47	140–150	0.30
60–70	2.14	150–160	0.23
70–80	1.66	160–170	0.15
80–90	1.97	170–180	0.09

[1]Based on data from Baird et al. (2000)

2.2.1.2.5 *Balaenoptera edeni*, Bryde's Whale

Bryde's whales are found in tropical and temperate waters, with separate coastal and offshore forms (Best 2001; Weir 2007). There is ongoing debate about the taxonomic relationship between two morphotypes — the larger -*brydei* form, found within the AFTT and HSTT Study Areas, and the smaller -*edeni* form, found outside of the AFTT and HSTT study areas (Sasaki et al. 2006). These two forms are genetically distinct, and are differentiated by geographic distribution, inshore/offshore habitat preferences, and size. However, for both morphotypes, which are not easily distinguished at sea, the scientific name *B. edeni* is commonly used. The main prey of Bryde's whales include pelagic schooling fish species, such as sardines, mackerel, and herring (Siciliano et al. 2004), as well as cephalopods and small crustaceans (Kato 2002; Omura 1962).

In order to build a representative depth distribution for Bryde's whales, data from Table 1 in Alves et al. (2010) were used. Alves et al. (2010) reported a distribution of time spent in shallow versus deep dives for two whales tagged with a time-depth recorder near Madeira Island, Spain. Though these data are not strictly an indication of time spent in the two different depth bins (time spent diving to 40-292 m includes time passing through the 0-40 m depth bin), the data are the best available approximation of time spent at depth. The depth distribution for Bryde's whales is given in Table 2-9.

Table 2-9. Percentage Time at Depth for the Bryde's Whale[1,2]

Depth Bin (m)	% of Time at Depth
0–40	84.5
40–292	15.5

[1]Based on data from Alves et al. (2010)
[2]This depth distribution is also representative of the sei whale

2.2.1.2.6 *Balaenoptera borealis*, Sei Whale

Sei whales have a cosmopolitan distribution, migrating between high latitude feeding grounds and low latitude breeding grounds (Horwood 2002). Sei whales are capable of diving for between 5 and 20 min (Reeves et al. 2002) to feed on plankton, predominantly copepods and euphausiids, which occur between the surface and depths around 150 m (Budylenko 1978; Flinn et al. 2002). They may also feed on small schooling fish and cephalopods by both gulping and skimming.

Little data have been collected on the dive behavior of sei whales. Sei whales are not thought to be deep divers. Baumgartner et al. (2011) found that sei whales were absent during times when copepods were at

depth, suggesting that sei whales may only be able to feed effectively on copepod aggregations when they are at or near the surface. In addition, Baumgartner and Fratantoni (2008) observed low calling rates during the night when copepods were at the surface, and higher calling rates during the day when copepods were at depth. This study speculated that sei whales reduced calling rates to accommodate nighttime feeding on the copepod aggregations at the surface, and increased calling rates during the day when copepods migrated to deeper depths where they were unavailable as prey to the sei whales.

Due to a lack of available data on the dive behavior of sei whales, they will be represented by a surrogate species: the Bryde's whale (Section 2.2.1.2.5). The Bryde's whale is the closest relative to the sei whale (Sasaki et al. 2005); these species are of similar body size (Horwood 2002) and feed on similar prey in the Northern Hemisphere (Flinn et al. 2002; Mizroch et al. 1984). While sei whales differ from other Balaenopterids in their prey preference for copepods, this preference means that, like Bryde's whales, sei whales are not thought to be deep divers and spend most of their time near the surface (Alves et al. 2010). Foraging sei whales and Bryde's whales utilize similar water depths (Alves et al. 2010; Baumgartner et al. 2011). The depth distribution for the sei whale can be found in Table 2-9.

2.2.1.3 Family Delphinidae

2.2.1.3.1 Orcinus orca, Killer Whale

Killer whales have a cosmopolitan distribution, but are most commonly observed in temperate, coastal waters (Ford 2002). Killer whales feed on a variety of prey, although most populations exhibit some degree of dietary specialization. In the northeastern Pacific and Antarctic, sympatric populations in each location are socially (and, in some cases, reproductively) isolated by foraging specializations for fish or marine mammal species (Ford et al. 1998; Pitman and Ensor 2003; Saulitis et al. 2000).

Due to a separation of diving behaviors based on preferred prey of the killer whale, two separate representative depth distributions were compiled for killer whales: fish-eating killer whales and mammal-eating killer whales. Fish-eating killer whales have been studied more extensively than mammal-eating ecotypes, although there is still limited published information on diving behavior of either. Fish-eating killer whales will either chase individual prey at the surface, or collectively herd schooling fish towards the surface (Domenici et al. 2000; Nøttestad et al. 2002). Mammal-eating killer whales have different foraging strategies than fish-eating killer whales (Barrett-Lennard et al. 1996; Pitman and Ensor 2003). Mammal-eating killer whales often attempt to capture prey from below, where a prey's silhouette against brighter surface waters may improve detection. Miller et al. (2010) found deeper dives for mammal-eating killer whales occurred during the day.

In order to build a representative depth distribution for fish-eating killer whales, data from Figure 2 in Sivle et al. (2012), Figure 1e in Kvadsheim et al. (2012), as well as plots from post sonar exposure and/or silent pass of the ship from Miller et al. (2011) were used. Since all three studies analyzed the potential effects of sonar on the dive behavior of killer whales, only dive profiles from periods of time when no sonar was active were used. Depth distributions were extracted from the presented dive profiles. Individual depth distributions for each animal were averaged to create the representative depth distribution in Table 2-10. This representative depth distribution is consistent with Baird (1994) and Shapiro (2008), who reported that fish-eating resident killer whales spent the vast majority of their time in the top 20 m. The depth distribution for killer whales is given in Table 2-10. The deepest killer whale dive recorded thus far was to 264 m by Baird et al. (2005a), who

tagged a total of 34 Southern Resident killer whales. However, the average of all the tagged killer whale deepest dives was 141 m, which is consistent with the depth distribution in Table 2-10.

Table 2-10. Percentage of Time at Depth for Fish-Eating Killer Whales[1]

Depth Bin (m)	% of Time at Depth
0–20	81.51
20–40	8.60
40–60	4.45
60–80	2.37
80–100	2.12
100–120	0.53
120–140	0.32
140–150	0.18

[1]Based on data from Kvadsheim et al. (2012), Miller et al. (2011), and Sivle et al. (2012)

In order to build a representative depth distribution for mammal-eating killer whales (Table 2-11), data from Figure 5 in Miller et al. (2010) and Figure 2.5B from Baird (1994) were used. Based on visual inspection and interpretation of the Figures provided by Miller et al. (2010), an average dive distribution was created for the presented whales; visual inspection was also used to build a depth distribution from the Figure presented by Baird (1994). The calculated data from Miller et al. (2010) were weighted by a factor of 11 when creating the final dive profile for mammal-eating killer whales, due to the presence of 11 animals in that study compared to one presented by Baird (1994).

Table 2-11. Percentage of Time at Depth for Mammal-Eating Killer Whales[1]

Depth Bin (m)	% of Time at Depth
0–10	42.91
10–20	23.32
20–30	13.94
30–40	8.27
40–50	5.97

Depth Bin (m)	% of Time at Depth
50–60	2.46
60–70	1.66
70–80	0.82
80–100	0.36

[1]Based on data from Baird (1994) and Miller et al. (2010)

2.2.1.3.2 *Stenella frontalis,* Atlantic Spotted Dolphin

The Atlantic spotted dolphin is usually found in shallow, continental shelf waters. Atlantic spotted dolphins feed on both mesopelagic fish and squid, as well as benthic invertebrates (Perrin et al. 1994a). In the Bahamas, the Atlantic spotted dolphin diet consists of, in order of highest consumption: flying fish (Family Exocoetidae), squid (*Doryteuthis spp.*), needlefish (Family Belonidae), and ballyhoo/half beaks (Family Hemiramphidae) (Herzing and Elliser 2013).

In order to build a representative depth distribution for Atlantic spotted dolphins, data from Table 1 in Davis et al. (1996) were used. Davis et al. (1996) tracked a tagged dolphin in water with a mean depth of 32.6 m (range 12–63 m), and indicated that it was consistently diving deep enough to reach the seafloor. Davis et al. (1996) reported no diel pattern in the depth of dives. The depth distribution for Atlantic spotted dolphins is given in Table 2-12.

Table 2-12. Percentage of Time at Depth for the Atlantic Spotted Dolphin[1]

Depth Bin (m)	% of Time at Depth
0–10	76.2
10–20	11.4
20–30	8.3
30–40	2.9
40–60	1.4

[1]Based on data from Davis et al. (1996)

This representative depth distribution is consistent with tagging results from Griffin (2005), who reported dolphins diving to the seafloor at 30 m, with animals spending most of their time in the top 10 m. While Atlantic spotted dolphins are often observed in deeper water than 60 m (Davis et al. 1998; Herzing and Elliser 2013), Herzing and Elliser (2013) observed Atlantic spotted dolphins near Little Bahama Bank spending most of the day in shallow water and moving into deeper water when the deep scattering layer rises after dark to forage.

2.2.1.3.3 *Steno bredanensis*, Rough-toothed Dolphin

Rough-toothed dolphins are commonly found in waters along the continental shelf in tropical and warmer temperate waters (Davis et al. 1998). Rough-toothed dolphins have been reported feeding on squids and fishes near the surface, which may indicate that they primarily make shallow dives (Lodi and Hetzel 1999; Pitman and Stinchcomb 2002).

In order to build a representative depth distribution for rough-toothed dolphins, data from Table 9 in Wells et al. (2008) were used. Wells et al. (2008) reported time-at-depth data from four rehabilitated and released adult rough-toothed dolphins in the Atlantic Ocean and presented the percentage of dives to greater than 2 m for each animal. While these data underestimate surface time (since an animal had to dive below 2 m depth for the tag to save the data), they indicate that rough-toothed dolphins spend the majority of their time in the upper 25 m of the water column. Only two of the four dolphins (three dives total) reached the 200–300 m depth bin, and dives were generally shallowest during the daytime. The data from Wells et al. (2008) were averaged across all four animals. The depth distribution for rough-toothed dolphins is given in Table 2-13.

Table 2-13. Percentage of Time at Depth for the Rough-Toothed Dolphin[1]

Depth bin (m)	% of Time at Depth
0–10	78.0
10–25	16.2
25–50	3.8
50–75	0.9
75–100	0.3
100–150	0.1
150–200	0.01
200–300	0.01

[1]Based on data from Wells et al. (2008)

Other than the Wells et al. (2008) study, little data have been collected on the dive behavior of the rough-toothed dolphin. An early study by Watkins et al. (1987) reported rough-toothed dolphins rubbing against a deployed hydrophone at a depth of 70 m.

2.2.1.3.4 *Tursiops truncatus*, Bottlenose Dolphin

Bottlenose dolphins have a cosmopolitan distribution in the tropical and temperate waters of the world (Wells and Scott 2002). They reside in estuarine, coastal, and offshore continental shelf and slope waters. Populations vary in their migratory and foraging behavior (Wells and Scott 2002). Bottlenose dolphins feed primarily on fish species, with squid and other invertebrates contributing to their diet as well (National Marine Fisheries Service 2015). Due to the range of habitats in which bottlenose dolphins are found, prey species may be epipelagic, pelagic, mesopelagic, or benthic in origin, depending on the region and habitat (Mead and Potter 1990; Rossbach and Herzing 1997; Shane 1990; Wells and Scott 1999). The presence of deep-sea fish in the stomachs of some offshore animals suggests that they can dive to depths greater than 500 m (Reeves et al. 2002).

Little data have been collected on the dive behavior of bottlenose dolphins. In order to build a representative depth distribution for bottlenose dolphins, data from Table 4 in Klatsky (2004) were used. Dolphins 39999 and 40000 were tagged for 30 and 48 hours, respectively, whereas Dolphin 40001 was tracked for 45 days, providing 792 hours of dive data. So, while Klatsky (2004) presents the percentage of time at depth for three individuals, only the data from Tag 40001 were considered for the depth distribution in order to provide the most comprehensive view of bottlenose dolphin diving behavior. Klatsky (2004) reported that the maximum recorded depth of a dolphin was 492 m, therefore, that was used as the maximum depth associated with this depth distribution. The depth distribution for bottlenose dolphins is given in Table 2-14.

Table 2-14. Percentage of Time at Depth for the Bottlenose Dolphin[1]

Depth bin (m)	% of Time at Depth
0–6	64.6
6–10	3.9
10–26	5.7
26–50	2.5
50–76	2.0
76–100	1.7
100–150	3.6
150–200	2.5
200–250	2.1
250–300	2.2
300–350	1.9
350–400	1.7
400–450	1.6
400–492	4.0

[1]Based on data from Klatsky et al. (2004)

These data are consistent with animals foraging up to 500 m off Hawaii, and spending the majority of their time between the surface and 50 m (Baird et al. 2014).

2.2.1.3.5 *Globicephala macrorhynchus*, Short-finned Pilot Whale

Short-finned pilot whales occur in tropical and warm-temperate waters along the continental shelf and slope (Davis et al. 1998). Short-finned pilot whales feed pre-dominantly on squid, but they also feed on octopus and fish occasionally (Mintzer et al. 2008; Reeves et al. 2002). On the U.S. Pacific coast the neritic cephalopod, *Loligo* spp., is the dominant prey (Mintzer et al. 2008). Short-finned pilot whales feed on vertically migrating prey, diving deep during dusk and dawn and staying near surface at night (Baird et al. 2003).

In order to build a representative depth distribution for short-finned pilot whales, data from Figure 9 in Wells et al. (2013) were used. Wells et al. (2013) tagged two male pilot whales after a mass stranding event in the Florida Keys. However, one of the individual tags stopped transmitting after 16 days, but the other tag transmitted for a total of 67 days; thus, the representative depth distribution contains only the Wells et al. (2013) data from the individual with the longer transmission time. Due to the lack of data on time spent at depth, the proportion of dives made to specific depth ranges from Wells et al. (2013) will be used as a proxy for percentage of time spent at depth. The depth distribution for short-finned pilot whales is given in Table 2-15.

Table 2-15. Percentage of Time at Depth for the Short-Finned Pilot Whale[1,2]

Depth Bin (m)	% of Time at Depth
0–2	32.25
2–50	46.75
50–100	3.00
100–200	5.00
200–300	4.25
300–400	2.75
400–500	1.75
500–600	1.75
600–700	1.75
700–800	0.5
800–900	0.125
900–1,000	0.125

[1]Based on data from Wells et al. (2013)
[2]This depth distribution is also representative of the following species: the long-finned pilot whale, pilot whale guild, Fraser's dolphin, pygmy sperm whale, dwarf sperm whale, and *Kogia* spp. guild

Aguilar Soto et al. (2008) reported a maximum dive depth of 1019 m for 23 whales near the Canary Islands, which is similar to the deepest depth bin in Table 2-15. While the maximum depth in Jensen et al. (2011) (roughly 700 m) is hundreds of meters shallower than in the distribution above, the total time spent deeper than this depth constitutes a very small percentage of the whale's total time.

2.2.1.3.6 *Globicephala melas,* Long-finned Pilot Whale

Long-finned pilot whales are commonly found in cold and temperate continental shelf and slope waters (Buckland et al. 1993; Payne and Heinemann 1993). Long-finned pilot whales prey on epipelagic, mesopelagic, and demersal squid and fish (Desportes and Mouritsen 1993; Gannon et al. 1997).

In order to build a representative depth distribution for long-finned pilot whales, data from Table 2 from Heide-Jorgensen et al. (2002) were used. The maximum reported dive depth was 828 m. Data from the individual whales of different sexes and sizes, as well as in a variety of locations, were rounded to sum to 100 percent of each individual whale's time, then averaged together to create the depth distribution given in Table 2-16.

Table 2-16. Percentage of Time at Depth for the Long-Finned Pilot Whale[1]

Depth Bin (m)	% of Time at Depth
0–17	74.4
18–35	5.2
36–53	2.2
54–101	3.8
102–149	2.8
150–197	1.8
198–299	3.4
300–401	2.6
402–599	2.9
600–797	0.9

[1]Based on data from Heide-Jorgensen et al. (2002)

Maximum reported dive depths for long-finned pilot whales range differ by location, including a depth of 513 m off the coast of Norway (Aoki et al. 2013) and a depth of 648 m in the Mediterranean Sea (Baird et al. 2002). Long-finned pilot whales show some diurnal variation in diving behavior, with the deepest dives occurring shortly after sunset when the whales may target vertically-migrating prey (Baird et al. 2002). Mate et al. (2005) reported whales spending between 5.6 and 47.4 percent of their time at the surface, while Hooker et al. (2011) found long-finned pilot whales spending an average of 67 percent of time in the top 10 m of the water column. The representative depth distribution in Table 2-16 is consistent with distribution data reported in Table 1 in Nawojchik et al. (2003), Figures 3a and 8a in Aoki et al. (2013), Figure 3 in Sivle et al. (2012), and plots from post sonar exposure and silent passes of a ship in Miller et al. (2011).

Despite the presence of depth distribution data for long-finned pilot whales, there is a lack of available separate density data for each species of pilot whale. As a result, the two species must be represented by one depth distribution. After comparing the depth distribution given in Table 2-16 with the depth distribution for the short-finned pilot whale given in Table 2-15, the short-finned pilot whale (Section 2.2.1.3.5) data were selected as the representative depth distribution for use. The short-finned pilot whale data represent a majority of time spent in the top 50 m of the water column rather than at depth. Both pilot whales are members of the same subfamily, Globicephalinae, feed on mesopelagic prey, and are similar in size. The depth distribution for long-finned pilot whales can be found in Table 2-15.

2.2.1.3.7 Pilot Whale Guild

Within the AFTT Study Area, the distributions of short-finned and long-finned pilot whales overlap. As these two species are difficult to distinguish when viewing at sea, much of the density data from surveys are reported as generic "pilot whales." Because the short-finned pilot whale depth distribution found in Table 2-15 was selected as the representative depth distribution for both species of pilot whale, these data also represent the depth distribution for the pilot whale guild. Within this guild, the best available estimate of the population of short-finned pilot whales in the western North Atlantic is 37,112 short-finned pilot whales. As compared to the best available estimate of long-finned pilot whales (at 5,636 long-finned pilot whales), the short-finned pilot whale has a significantly larger population size in the AFTT Study Area (Barlow 2010; Barlow and Forney 2007; Forney 2007; Waring et al. 2016). Short-finned pilot whales also inhabit a larger geographic range, spanning from the western North Atlantic to the Gulf of Mexico, while long-finned pilot whales are only found in the western North Atlantic. The representative depth distribution for pilot whales can is given in Table 2-15.

2.2.1.3.8 *Lagenodelphis hosei*, Fraser's Dolphin

Fraser's dolphins are commonly found in the tropics worldwide in waters deeper than 1,000 m. While they do have occasional strandings in temperate waters, those are thought to be extralimital occurrences (Louella and Dolar 2002; Reeves et al. 2002).

Little data have been collected on the dive behavior of Fraser's dolphins. Robison and Craddock (1983) reported that the mesopelagic fish, shrimp, and squid species that were found in the stomachs of three dolphins typically inhabit depths between 250 and 500 m. Fraser's dolphins in the Sulu Sea, off the coast of the Philippines, were found to feed on vertically migrating species in the upper 200 m of the water column, as well as on non-migrating species found at depths below 600 m (Dolar et al. 2003). Fraser's dolphins have also been seen herding fish near the water's surface (Watkins et al. 1994).

Due to the lack of available data on the diving behavior of the Fraser's dolphin, it will be represented by a surrogate species: the short-finned pilot whale (Section 2.2.1.3.5). Dolar et al. (1999) found that Fraser's dolphins have myoglobin concentrations consistent with those of other deep-diving marine mammals, and relative muscle masses much greater than those of other dolphins their size, both of which are indicative of enhanced diving ability. Therefore, despite their smaller size, the Fraser's dolphin will be modeled as a short-finned pilot whale, another species in the family Delphinidae which feeds on mesopelagic and bathypelagic prey at similar deep depths (Desportes and Mouritsen 1993; Gannon et al. 1997). The depth distribution for the Fraser's dolphin is given in Table 2-15.

2.2.1.3.9 *Grampus griseus*, Risso's Dolphin

Risso's dolphins are commonly found in temperate and tropical waters along continental slopes (Azzellino et al. 2008; Baumgartner 1997; Green et al. 1992). Although little is known about their foraging or diving behavior, vertically migrating cephalopods are presumed to be the primary food source for Risso's dolphins (Clarke and Pascoe 1985).

In order to build a representative depth distribution, data from Figure 5 in Wells et al. (2009) were used. Wells et al. (2009) reported on the movement and diving behavior of a rehabilitated adult male Risso's dolphin that stranded on the Gulf coast of Florida. Based on Figure 5, the depth distribution for Risso's

dolphins was estimated for four 6-hour blocks of time. The tagged animal in this study travelled through waters with a mean depth of 548 m (range 3–2300 m), and was therefore likely not diving close to the seafloor. The deepest dive recorded on the tag was in the 400–500 m depth range, and less than 0.1 percent of dives were deeper than 200 m (Wells et al. 2009). The average time spent in these depth bins was calculated for the representative depth distribution. The depth distribution for the Risso's dolphin is given in Table 2-17.

Table 2-17. Percentage of Time at Depth for the Risso's Dolphin[1,2]

Depth Bin (m)	% of Time at Depth
0–1	24.8
1–2	13.5
2–10	16.5
10–50	43.5
50–100	1.2
100–150	0.1
150–600	0.4

[1]Based on data from Wells et al. (2009)
[2]This depth distribution is also representative of the following species: the pygmy killer whale, melon-headed whale, and false killer whale

2.2.1.3.10 *Feresa attenuata*, Pygmy Killer Whale

Pygmy killer whales inhabit tropical and subtropical waters of the continental slope and waters farther offshore (Donahue and Perryman 2002). Analyses of their stomach contents indicate that their primary prey include cephalopods and fish, although other marine mammals also constitute some portion of their diet (Mignucci-Giannoni et al. 1999; Perryman and Foster 1980). Some shallow water prey (from less than 200 m deep) have been reported in the stomachs of stranded pygmy killer whales, though these prey species may have been consumed as animals moved closer to shore prior to stranding (Sekiguchi et al. 1992; Zerbini and de Oliveira Santos 1997). Characteristics of their echolocation clicks indicate that pygmy killer whales could detect fish and cephalopod prey at distances of 50–200 m (Madsen et al. 2004b).

Due to a lack of available data on the dive behavior of pygmy killer whales, they will be represented by a surrogate species: the Risso's dolphin (Section 2. 2. 1. 3. 9). The closest relatives to the pygmy killer whale for which diving behavior have been studied are three members of the subfamily Globicephalinae: the short-finned pilot whale, the long-finned pilot whale, and the Risso's dolphin (LeDuc et al. 1999). The pygmy killer whale (at 2.3 m long) is closer in size to the Risso's dolphin (4 m) than to the pilot whales (6 m). Both pygmy killer whales and Risso's dolphins are found in deep water and feed on squid and other cephalopods. The depth distribution for the pygmy killer whale can be found in Table 2-17.

2.2.1.3.11 *Peponocephala electra*, Melon-headed Whale

Melon-headed whales occur in oceanic tropical and subtropical waters (Perryman et al. 1994). Melon-headed whales feed on a variety of mesopelagic fish (e.g., myctophids) and cephalopod species (Brownell Jr. et al. 2009; Gross et al. 2009; Jefferson and Barros 1997).

No data have been collected on the dive behavior of the melon-headed whale, although some inferences can be made from the primary prey species. Myctophids are vertical migrators that descend to depths of 700–

3,000 m during the day and rise to 200 m or less at night (Clarke 1973), when melon-headed whales are thought to feed (Brownell Jr. et al. 2009). Cephalopods are also vertical migrators, descending to depths of 400–700 m during the day and rising to 100–150 m at night (Young 1978).

Due to the lack of available data on the diving behavior of the melon-headed whale, it will be represented by a surrogate species: the Risso's dolphin (Section 0). Both species are members of the same subfamily, Globicephalinae, feed on mesopelagic prey, and are similar in size. The closest relative to the melon-headed whale is actually the pilot whale; however, pilot whales are more than twice the size of melon-headed whales (LeDuc et al. 1999). The small size of melon-headed whales may indicate that they do not dive as deeply as their larger relatives; thus, the Risso's dolphin is a more suitable surrogate species for dive behavior. The depth distribution for the melon-headed whale is given in Table 2-17.

2.2.1.3.12 *Pseudorca crassidens*, False Killer Whale

False killer whales inhabit tropical and temperate waters along and offshore of the continental slope (Odell and McClune 1999). Stomach content analyses have revealed that false killer whales feed on oceanic cephalopods (Alonso et al. 1999; Andrade et al. 2001), while observations indicate that they consume a variety of prey (including fish and other marine mammals) both at depth and at the surface (Acevedo-Gutiérrez et al. 1997; Perryman and Foster 1980; Stacey et al. 1994).

Little data have been collected on the dive behavior of the false killer whale. Cummings and Fish (1971) estimated that false killer whales would be capable of diving to depths up to 500 m. Based on measurements of their echolocation clicks, whales may detect large fish at up to 200 m distance and cephalopods at about half that distance (Madsen et al. 2004a), which may suggest false killer whales are capable of diving to at least 200 m. Unpublished time-depth recorder data of a single whale showed that all dives to deeper than 100 m occurred during the day, with a maximum depth exceeding 234 m (Baird 2009). Dives during the nighttime remained within the top 100 m of the water column. Ligon and Baird (2001) reported that three instrumented whales showed a maximum diving depth of 53 m, with an average dive depth range of 8–12 m; however, the time of day that the dives occurred was not reported.

Due to the lack of available data on the diving behavior of the false killer whale, it will be represented by a surrogate species: the Risso's dolphin (Section 2.2.1.3.9). The closest relatives to the false killer whale for which diving behavior have been studied are three members of the subfamily Globicephalinae: the short-finned pilot whale, the long-finned pilot whale, and the Risso's dolphin (LeDuc et al. 1999). False killer whales are in between these species in size, but the limited data suggest that false killer whales do not dive as deep as pilot whales. Risso's dolphins and false killer whales also both feed on pelagic cephalopods (Clarke and Pascoe 1985). The depth distribution for the false killer whale is given in Table 2-17.

2.2.1.3.13 *Stenella attenuata,* Pantropical Spotted Dolphin

Pantropical spotted dolphins are found in warm temperate and tropical waters over the continental slope and offshore in deeper waters (Perrin and Hohn 1994). Pantropical spotted dolphins feed on both epipelagic and mesopelagic fish and squid (Wang et al. 2003). In general, pantropical spotted dolphins dive deeper at night, foraging on prey associated with vertical migrations of the deep scattering layer (Robertson and Chivers 1997; Scott and Chivers 2009).

In order to build a representative depth distribution for pantropical spotted dolphins, data from Figure 4 and Table 2 in Baird et al. (2001) and Figure 9 and Table 2 in Scott and Chivers (2009) were used. While Baird et al. (2001) looked at pantropical spotted dolphin diving behavior around the Hawaiian Islands, Scott and Chivers (2009) recorded data on these dolphins in pelagic waters. Baird et al. (2001) reported pantropical spotted dolphins spend on average 88.5 percent of their time within 10 m of the surface during the day. Baird et al. (2001) reported the daytime average percentage of time in two meter intervals for the top 10 meters. For the Baird et al. (2001) nighttime and Scott and Chivers (2009) data, the percentage of time determined for the top 10 meters was uniformly distributed across these two meter intervals. Daytime and nighttime averages were calculated for the Baird et al. (2001) data, and these were then averaged with the Scott and Chivers (2009) data. The resulting mean daytime and nighttime depth distribution data are presented in Table 18. Baird reported maximum daytime and nighttime dive depths at 122 m and 213 m, respectively (Baird et al. 2001); however, Scott and Chivers (2009) calculated that dives to more than 120 m accounted for less than 0.1 percent of all dives. They also noted that daytime dives were primarily shallow and above the thermocline (Scott and Chivers 2009). The depth distribution for pantropical spotted dolphins is given in Table 2-18.

Table 2-18. Percentage of Time at Depth for the Pantropical Spotted Dolphin[1,2]

Depth Bin (m)	% of Time at Depth
0–2	20.4
2–4	10.7
4–6	8.6
6–8	9.0
8–10	9.5
10–20	21.3
20–30	8.8
30–40	3.8
40–50	2.5
50–60	1.9
60–70	1.1

Depth Bin (m)	% of Time at Depth
70–80	0.6
80–90	0.6
90–100	0.4
100–110	0.4
110–120	0.3
120–130	0.1
130–140	0.1
140–150	0.1
150–160	0.1
160–170	0.1

[1]Based on data from Baird et al. (2001) and Scott and Chivers (2009)
[2]This depth distribution is also representative of the following species: the long-beaked common dolphin, short-beaked common dolphin, Atlantic white-sided dolphin, white-beaked dolphin, Pacific white-sided dolphin, Northern Right whale dolphin, clymene dolphin, striped dolphin, and spinner dolphin

2.2.1.3.14 Delphinus capensis, Long-beaked Common Dolphin

It was not until the mid-1990s that the long-beaked common dolphin was separated from the short-beaked common dolphin as a distinct species (Heyning and Perrin 1994). Long-beaked common dolphins are thought to be coastal foragers, feeding mostly on pelagic fish, particularly those in the families Scombridae, Scianidae, and Serranidae (Niño-Torres et al. 2006) as well as krill and squid (Reeves et al. 2002).

No data have been collected on the dive behavior of the long-beaked common dolphin. Due to the lack of available data on the diving behavior of the long-beaked common dolphin, it will be represented by a surrogate species: the pantropical spotted dolphin (Section 2.2.1.2.13). The closest relative to the long-beaked common dolphin is the short-beaked common dolphin, which is also represented by the pantropical spotted dolphin. While the long-beaked common dolphin is considered a more coastal species than the

short-beaked common dolphin, in many areas their distributions overlap. The depth distribution of the long-beaked common dolphin can be found in Table 2-18.

2.2.1.3.15 *Delphinus delphis,* Short-beaked Common Dolphin

While species of common dolphins are sympatric in some nearshore continental shelf waters, short-beaked common dolphins are typically found in deeper waters along the continental slope (Cañadas and Hammond 2008; Heyning and Perrin 1994; Jefferson et al. 2009; Rosel et al. 1994; Selzer and Payne 1988). They feed on epipelagic and mesopelagic fish and squid (Selzer and Payne 1988), and also forage at night on vertically migrating prey associated with the deep scattering layer (Evans 1994; Neumann and Orams 2003; Ohizumi et al. 1998; Pusineri et al. 2007).

Little data have been collected on the dive behavior of the short-beaked common dolphin. Evans (1975; 1994) described the late afternoon and evening diving behavior of an adult female short-beaked common dolphin in the Pacific Ocean. Before 1730 the dolphin mostly remained in the top 10 m, at which time it switched to a pattern of regular dives to 50 m, with a maximum dive depth of just over 200 m (Evans 1974, 1994).

Due to the lack of available data on the diving behavior of the short-beaked common dolphin, it will be represented by a surrogate species: the pantropical spotted dolphin (Section 2.2.1.3.13). Pantropical spotted dolphins also make shallower dives during the day than at night, when they forage on vertically-migrating prey associated with the deep scattering layer (Scott and Chivers 2009). During the day, pantropical spotted dolphins spend 94 percent of their time in the top 20 m of the water column, while at night 95 percent of their time is spent in the top 50 m (Baird et al. 2001). Evans (1994) reported the maximum dive depth for three short-beaked common dolphins was 257 m. Similarly, maximum dive depths for pantropical spotted dolphins are 122 m for daytime and 213 m for nighttime (Baird et al. 2001). Pantropical spotted dolphins and common dolphins are members of the same subfamily, Delphinidae (LeDuc et al. 1999) and their behavior shows clear similarities in diving pattern, foraging behavior, and water column usage. The depth distribution of the short-beaked common dolphin is given in Table 2-18.

2.2.1.3.16 *Lagenorhynchus acutus,* Atlantic White-sided Dolphin

Atlantic white-sided dolphins are found in cold temperate and sub-polar waters, ranging from the continental shelf to further offshore of the continental slope (Palka et al. 1997). They feed on both epipelagic and mesopelagic fish and squid (Couperus 1997; Craddock et al. 2009; Doksaeter et al. 2008; Weinrich et al. 2001).

Little data have been collected on the dive behavior of Atlantic white-sided dolphins. One stranded and rehabilitated dolphin with a satellite tag provided basic dive behavior information (Mate et al. 1994). Over a six day period, no dives were longer than four minutes, and no surface durations lasted longer than one minute; the Atlantic white-sided dolphin spent 89 percent of its time beneath the surface at unknown depths. White-sided dolphins caught in bottom trawl and sink gillnet fisheries as bycatch were recovered in nets fished at a mean depth of 189.8 m (range 55–503 m), although the exact depths at which the animals were entangled are unknown (Craddock et al. 2009).

Due to the lack of available data on the diving behavior of the Atlantic white-sided dolphin, it will be represented by a surrogate species: the pantropical spotted dolphin (Section 2.2.1.3.13). Both species are

members of the same family, Delphinidae, and forage on similar vertically migrating prey species that come to the surface layer (above 200 m) at night (Scott and Chivers 2009; Wang et al. 2003). The depth distribution for the Atlantic white-sided dolphin is given in Table 2-18.

2.2.1.3.17 *Lagenorhynchus albirostris*, White-beaked Dolphin

White-beaked dolphins occur only in the temperate and subarctic North Atlantic Ocean, generally in coastal and continental shelf waters (Kinze 2002). Fish species constitute the primary prey of white-beaked dolphins (e.g., Atlantic cod, haddock, herring, and hake); however, cephalopods and benthic crustaceans are also part of their diet (Ostrom et al. 1993; Reeves et al. 1999). They have also been observed cooperatively herding schooling fish species at the surface (Reeves et al. 1999).

Little data have been collected on the dive behavior of the white-beaked dolphin. White-beaked dolphins generally prefer shallow waters less than 200 m deep (Jefferson et al. 2008). In the 1970s and 1980s, white-beaked dolphins off the northeastern U.S. Atlantic coast may have shifted habitats with Atlantic white-sided dolphins. During this time, white-beaked dolphins, which were normally found in inshore waters, moved offshore due to an increase in sand lance on the continental shelf and a decline in herring.

Due to the lack of available data on the diving behavior of the white-beaked dolphin, it will be represented by a surrogate species: the pantropical spotted dolphin (Section 2.2 1.3.13). The closest relative to the white-beaked dolphin is the Atlantic white-sided dolphin, which is also represented by the pantropical spotted dolphin. The depth distribution for the white-beaked dolphin can be found in Table 2-18.

2.2.1.3.18 *Lagenorhynchus obliquidens*, Pacific White-sided Dolphin

Pacific white-sided dolphins inhabit cold temperate waters of the North Pacific, in both offshore and coastal waters (Brownell et al. 1999; Waerebeek and Würsig 2002). Their primary prey species include mesopelagic fish and cephalopods, as well as epipelagic fish in shallower waters (Brownell et al. 1999; Kajimura and Loughlin 1988; Miyazaki et al. 1991; Morton 2000; Walker and Jones 1994).

Little data have been collected on the dive behavior of the Pacific white-sided dolphin. Hall (1970) trained a captive Pacific white-sided dolphin to dive to a depth of 214 m. However, Black (1994) reported that in coastal waters, 70 percent of dives were shorter than 20 seconds in duration, and dives longer than 90 seconds were rare, indicating that most dives are shallow. Heise (1997) similarly reported that 70 percent of foraging dives were less than 15 seconds in duration. Therefore, Pacific white-sided dolphins are not considered deep divers. This species is thought to feed mostly at night or in the morning (Stroud et al. 1981) when their mesopelagic prey rise to surface waters.

Due to the lack of available data on the diving behavior of the Pacific white-sided dolphin, it will be represented by a surrogate species: the pantropical spotted dolphin (Section 2.2.1.3.13). Pantropical spotted dolphins spend the majority of their time in the top 50 m, and their maximum diving depths are within the range of the dive depth of the trained Pacific white-sided dolphin (Baird et al. 2001; Hall 1970; Scott and Chivers 2009). Pantropical spotted dolphins and Pacific white-sided dolphins also feed on similarly migrating prey species. The depth distribution for the Pacific white-sided dolphin can be found in Table 2-18.

2.2.1.3.19 *Lissodelphis borealis,* Northern Right Whale Dolphin

The northern right whale dolphin is abundant in deep, temperate waters across the North Pacific Ocean (Forney and Barlow 1998; Jefferson and Newcomer 1993b; Leatherwood and Walker 1979; Rankin et al. 2007). They are known to commonly associate with Pacific white-sided dolphins and Risso's dolphins (Forney and Barlow 1998; Jefferson and Newcomer 1993b), with which they show dietary overlap (Walker and Jones 1994). Northern right whale dolphins near the southern California coast feed principally on cephalopods and a diverse variety of myctophid fish (Jefferson and Newcomer 1993a; Jefferson et al. 1994; Leatherwood and Walker 1979).

Little data have been collected on the dive behavior of the Northern right whale dolphin. Some evidence based on stomach contents suggests that northern right whale dolphins may dive as deep as 200 m (Fitch and Brownell 1968; Jefferson et al. 1994). Individual northern right whale dolphins have been observed to dive for brief periods (10 to 75 seconds), but can also remain submerged for up to 6.5 min (Cruickshank and Brown 1981; Leatherwood and Walker 1979). Northern right whale dolphins have comparatively low muscle myoglobin content among odontocetes, suggesting they are not deep divers (Noren and Williams 2000).

Due to the lack of available data on the diving behavior of the northern right whale dolphin, it will be represented by a surrogate species: the pantropical spotted dolphin (Section 2.2.1.3.13). Of the two dolphins with which the northern right whale dolphin associates the most, the Risso's dolphin is considered a much deeper diver than the Pacific white-sided dolphin. Because northern right whale dolphins have low muscle myoglobin content and are thought to feed on prey only as deep as 200 m, they are thought to be shallower divers. Therefore, due to dietary similarity and frequent association with the Pacific white-sided dolphin, the northern right whale dolphin will be represented by the same surrogate species, the pantropical spotted dolphin. The depth distribution for the Northern right whale dolphin can be found in Table 2-18.

2.2.1.3.20 *Stenella coeruleoalba*, Striped Dolphin

Striped dolphins prefer tropical and warm temperate waters and have an oceanic distribution, with most observations occurring beyond the continental shelf (Archer II 2002; Cañadas et al. 2002; Davis and Fargion 1996; Davis et al. 1998; Perrin et al. 1994b). Striped dolphins primarily feed on small, pelagic, vertically migrating prey (Blanco et al. 1995). Stomach contents analyses suggest that foraging occurs mostly in the dusk and early evening hours (Ringelstein et al. 2006). Their distribution in the North Atlantic Ocean is associated with a mesopelagic prey community comprised of fish and cephalopod species (Doksaeter et al. 2008).

Little data has been collected on the dive behavior of the striped dolphin. A single striped dolphin carrying a time-depth recorder dove to a mean depth of 22.6 m (standard deviation (SD)=17.5)) during the day and 126.7 m (SD=120.9) at night, with a maximum dive depth of 705 m (Minamikawa et al. 2003).

Due to the lack of available data on the diving behavior of the striped dolphin, it will be represented by a surrogate species: the pantropical spotted dolphin (Section 2.2.1.3.13). The observed pattern of shallow daytime shallow diving and deeper nighttime diving reported in Minamikawa et al. (2003) is consistent with similar diving behavior seen in short-beaked common dolphins (Section 2.2.1.3.15) and their surrogate species, pantropical spotted dolphins (Section 2.2.1.3.13) which is also in the genus *Stenella*. Additionally, all three species occur in similar water depths (Davis et al. 1998). However, it is acknowledged that the striped

dolphin may dive to deeper depths on average, due to the deep maximum dive depth recorded by Minamikawa et al. (2003). The depth distribution for striped dolphins is given in Table 2-18.

2.2.1.3.21 *Stenella longirostris*, Spinner Dolphin

Spinner dolphins typically reside in tropical pelagic waters, although they have a coastal distribution around the Hawaiian and French Polynesia island chains (Benoit-Bird and Au 2003). The prey of spinner dolphins consists of vertically migrating mesopelagic fish, cephalopods, and crustaceans, as well as pelagic organisms concentrated in near-surface waters with a shallow thermocline (Lammers 2004; Reilly 1990).

No data have been collected on the dive behavior of the spinner dolphin. Many of the vertically migrating prey of the spinner dolphin spend daytime hours at depths from 700–3,000 m, but ascend to depths between the surface and 200 m at night. Spinner dolphins in Hawaiian waters mostly forage in deep water at dusk and early evening, but dive to shallow depths due to the vertical migration of their prey at night (Benoit-Bird and Au 2003; Lammers 2004).

Due to the lack of available data on the diving behavior of the spinner dolphin, it will be represented by a surrogate species: the pantropical spotted dolphin (Section 2.2.1.3.13). Pantropical spotted dolphins also forage mostly at night on vertically migrating fish and cephalopod prey and their foraging dives are primarily limited to the upper 200 m of the water column (Baird et al. 2001). Gross et al. (2009) found no niche differentiation between the two species. The depth distribution for striped dolphins can be found in Table 2-18.

2.2.1.3.22 *Stenella clymene*, Clymene Dolphin

Clymene dolphins are found in deep tropical and warm temperate waters beyond the continental shelf (Jefferson 2002a). The limited information available regarding their prey suggests they primarily feed on squid and vertically migrating myctophid fish, which are associated with the deep scattering layer (Perrin et al. 1981).

No data has been collected on the dive behavior of the Clymene dolphin. Some authors have speculated that their size limits them to the upper 250 m of the water column (Davis et al. 1998), although preliminary evidence suggests similarly-sized striped dolphins are capable of diving much deeper (Minamikawa et al. 2003).

Due to the lack of available data on the diving behavior of the Clymene dolphin, it will be represented by a surrogate species: the pantropical spotted dolphin (Section 2.2.1.3.13). Also in the genus *Stenella* and a shallower diver amongst the dolphin species, striped and spinner dolphins are the Clymene dolphin’s closest relatives. Thus, the Clymene dolphin will be represented by the same surrogate species, the pantropical spotted dolphin. The depth distribution for the Clymene dolphin is given in Table 2-18.

2.2.1.4 Family Eschrichtiidae

2.2.1.4.1 *Eschrichtius robustus*, Gray Whale

Gray whales are distributed coastally throughout the Pacific Ocean, migrating annually between Arctic and subtropical waters (Jones and Swartz 2002; Swartz 1986). Gray whales forage within the water column with

modified skimming techniques to capture neritic fish, and will scrape along the benthos to acquire benthic fish, squid, annelids, crustaceans, and mollusks (Darling et al. 1998; Dunham and Duffus 2002; Jones and Swartz 2002; Nerini 1984). Gray whales have been reported foraging in water up to 120 m deep (Cacchione et al. 1987; Dunham and Duffus 2002; Würsig et al. 1986), although in many areas whales forage in waters less than 20 m deep (Guerrero 1989; Ljungblad et al. 1987; Malcolm and Duffus 2000; Malcolm et al. 1995; Stewart et al. 2001; Woodward and Winn 2006).

In order to build a representative depth distribution for gray whales, data from Figure 3 in Malcolm et al. (1995) were used. Malcom et al. (1995) reported the percentage of time at depth for a single foraging whale carrying a tag for over 8 hours in waters off British Columbia in an area with a mean bottom depth of 18 m. The majority of dives (76 percent) were ventilation dives (to a mean depth of 2.3 m), while 13 percent were feeding dives (to a mean depth of 16.7 m). The whale appeared to spend little time at intermediate depths within the water column, spending most of its time either at the surface breathing or at the bottom feeding. Due to the large size of gray whales, the data from Malcom et al. (1995) was summed into four-meter bins for the representative depth distribution. The depth distribution for gray whales is given in Table 2-19.

Table 2-19. Percentage of Time at Depth for the Gray Whale[1]

Depth Bin (m)	% of Time at Depth
0–4	39.0
4–8	8.5
8–12	7.0
12–16	16.0
16–20	28.0
20–22	1.5

[1]Based on data from Malcom et al. (1995)

While other studies did not include depth distributions for gray whales, they did provide additional information to categorize dive behavior. The representative depth distribution data compare to a later study with a larger sample size of whales, where 79 percent of dives by whales off Vancouver Island were to a mean depth of 2.2 m, and 15 percent of dives were to a mean depth of 12–19 m (Malcolm and Duffus 2000). Woodward and Winn (2006) and Woodward (2006) similarly reported that six whales feeding along the central British Columbia coast had a mean dive depth of 11 m (range 2.4–28.9 m). The percentage of time near the surface (19.5 percent from 0-2 m) is also consistent with other studies in the same region (14.2 percent and 17.5 percent) (Stelle et al. 2008) and in the Bering Sea (22 percent) (Würsig et al. 1986). Furthermore, the dive depth is similar to the reported foraging depths in British Columbia and other regions (Guerrero 1989; Ljungblad et al. 1987; Malcolm and Duffus 2000; Malcolm et al. 1995; Stewart et al. 2001; Woodward and Winn 2006). Stewart et al. (2001) described the diving behavior post-release for a rehabilitated calf in southern California. All dives were less than 20 m deep, and 85 percent of dives were less than 10 m deep. An earlier release of a post-rehabilitated calf in the same area documented a much deeper maximum diving depth (170 m) and an average diving depth of approximately 50 m (Evans 1974), which is deeper than the that in the representative depth distribution.

2.2.1 5 Family Kogiidae

2.2.1.5.1 Kogia breviceps, Pygmy Sperm Whale

Pygmy sperm whales have a cosmopolitan distribution in all temperate and tropical waters (Bloodworth and Odell 2008). Mid- and deep-water cephalopods predominantly contribute to the diet of the pygmy sperm whale (Beatson 2007; Bloodworth and Odell 2008; Fernandez et al. 2009; McAlpine et al. 1997; Ross 1979; Santos et al. 2006).

Little data have been collected on the dive behavior of pygmy sperm whales. Sightings of pygmy sperm whales in the North Atlantic are most common in waters ranging from 400 to 1,000 m in depth (Clarke 2003; Scott et al. 2001; Waring et al. 2006). Based on the analysis of the stomach contents of whales stranded in New Zealand, Beatson (2007) concluded that pygmy sperm whales feed at shallower depths within the water column than sperm whales, although some prey species are found at depths greater than 600 m. Ploen (2004) found that prey species from the stomachs of stranded pygmy sperm whales in South Africa are found at depths below 300 m.

Due to the lack of available data on the diving behavior of the pygmy sperm whale, it will be represented by the surrogate species: the short-finned pilot whale (Section 2.2.1.3.5). The short-finned pilot whale is another primarily squid-eating species (Mintzer et al. 2008; Reeves et al. 2002) which forages deep in the water column (Jensen et al. 2011). The broad similarity in prey types and oceanic habitat suggests similarity in diving behavior to the short-finned pilot whale. The depth distribution for the pygmy sperm whale can be found in Table 2-15.

2.2.1.5.2 *Kogia sima,* Dwarf Sperm Whale

Dwarf sperm whales have a cosmopolitan distribution in all temperate and tropical waters (Willis and Baird 1998). Little data have been collected on the dive behavior of dwarf sperm whales. There is some indication that dwarf sperm whales have a more coastal distribution than pygmy sperm whales, and prey often include more continental shelf and slope species than those of the pygmy sperm whale (Ross 1979; Wang et al. 2002). The preferred prey species of dwarf sperm whales are found deep in the water column, with some species found below 400 m (Wang et al. 2002).
Due to lack of available data on the diving behavior of the dwarf sperm whale, it will be represented by the surrogate species: the short-finned pilot whale (Section 2.2.1.3.5). The broad similarity in depth at which preferred prey can be found and oceanic habitat suggests similarity in diving behavior to the short-finned pilot whale. In addition, the dwarf sperm whale’s closest relative, the pygmy sperm whale, is also represented by the short-finned pilot whale. The depth distribution for the dwarf sperm whale can be found in Table 2-15.

2.2.1.5.3 *Kogia* spp. *G*uild

Within the AFTT Study Area, the two *Kogia* species are difficult to distinguish when viewed at sea and are found in overlapping areas within the AFTT study area, as well as the Southern California portion of the HSTT Study Area. Therefore, much of the density data from surveys is combined for both species into a generic *Kogia* spp. guild. Because the depth distributions for both *Kogia* species are represented by the short-finned pilot whale, these data also represent the depth distribution for the *Kogia* spp. guild. Therefore, the depth distribution for *Kogia* spp. whales can be found in Table 2-15.

2.2.1 6 Family Phocoenidae

2.2.1.6.1 *Phocoena phocoena*, Harbor Porpoise

Harbor porpoises inhabit temperate and sub-arctic continental shelf waters in the northern hemisphere. Their diet consists primarily of fish, including both pelagic schooling and benthic species (Bjorge and Tolley 2002; Recchia and Read 1989). Cephalopods, crustaceans, euphausids, and polychaetes also contribute to their overall diet (Recchia and Read 1989; Smith and Read 1992; Walker et al. 1998).

In order to build a representative depth distribution for harbor porpoises, data from Figure 3 in Otani et al. (1998), Figures 2 and 3 in Westgate et al. (1995), Figure 1 in Otani et al. (2000), Figures 2, 3, and 4 in Cooper et al. (1993), and Figure 7 in Westgate and Read (1998) were used. Cooper et al. (1993) reported that porpoises in the Bay of Fundy were capable of diving to 150 m, but spent most of their time in the top 50 m of the water column. Westgate et al. (1995) reported porpoises diving to a maximum of 226 m, but that average dive depth for individual porpoises ranged from 14–41 m, and the depth range with the greatest proportion of dives was 2–10 m. Otani et al. (1998) found that harbor porpoises off the coast of Japan spent 74–86 percent of their time in the top 20 m of the water column, with an average dive depth of 12–19 m. The time at depth was visually inspected and averaged from all of the above Figures to create the depth distribution for the harbor porpoise. This was done to include a total of 14 different harbor porpoises into the dive distribution. While data from Cooper (1993), Otani (1998), and Westgate et al. (1995) show the number or frequency of dives to specific depth bins, this data will be used as a proxy for percentage of time spent at depth. The depth distribution for harbor porpoises is given in Table 2-20.

Table 2-20. Percentage of Time at Depth for the Harbor Porpoise[1]

Depth Bin (m)	% of Time at Depth	Depth Bin (m)	% of Time at Depth
0–10	39.02	110–120	0.26
10–20	17.79	120–130	0.35
20–30	12.74	130–140	0.34
30–40	10.14	140–150	0.23
40–50	6.90	150–160	0.16
50–60	4.61	160–170	0.06
60–70	2.52	170–180	0.06
70–80	1.50	180–190	0.06
80–90	1.37	190–200	0.06
90–100	0.98	200–210	0.06
100–110	0.31	210–226	0.06

[1]Based on data from Cooper (1993), Otani et al. (2000), Otani et al. (1998), Westgate and Read (1998), and Westgate et al. (1995)

While other studies did not include depth distributions for harbor porpoises, they did provide additional information to categorize dive behavior. In a study by Linnenschmidt et al. (2013) three harbor porpoises were tagged; two of the harbor porpoises showed consistent diving activity throughout the day while one harbor porpoise showed a diel diving pattern with few dives during the day. Teilmann et al. (2013) found harbor porpoises spent more time between 0 to 2 m at night than during the day; this may be due to the movement of their prey throughout the water column (e.g., herring [*Clupea harengus*] and sprat [*Sprattus sprattus*]) (Cardinale et al. 2003).

2.2.1.6.2 *Phocoenoides dalli*, Dall's Porpoise

Dall's porpoises can be found in the subarctic and cool temperate North Pacific Ocean, including the Bering Sea, Okhotsk Sea, and Sea of Japan (Jefferson 2002b). Primary prey species include epipelagic and mesopelagic schooling fish and cephalopod species (Jefferson 1988; Ohizumi et al. 2000; Stroud et al. 1981; Walker 1996).

In order to build a representative depth distribution for the Dall's porpoise, data from Figures 3 and 4 in Baird and Hanson (1998) were used. Baird and Hanson (1998) tagged three Dall's porpoises with time-depth recorders in the waters between Washington State and British Columbia. Each animal had a median dive depth of less than 40 m, and maximum dive depths ranged from 197–278 m. Data from the tagged Dall's porpoises were averaged together to create the representative depth distribution below. The depth distribution for Dall porpoises is given in Table 2-21.

Table 2-21. Percentage of Time at Depth for the Dall's Porpoise[1]

Depth Bin (m)	% of Time at Depth	Depth Bin (m)	% of Time at Depth
0–1	5.33	50–60	4.75
1–2	15.67	60–70	4.67
2–3	8.83	70–80	3.83
3–4	3.17	80–90	2.25
4–5	3.75	90–100	2.00
5–6	1.67	100–110	1.08
6–7	1.00	110–120	0.67
7–8	1.33	120–130	0.42
8–9	1.25	130–140	0.50
9–10	1.83	140–150	0.42
10–11	1.33	150–160	0.33
11–20	11.67	160–170	0.25
20–30	8.33	170–180	0.33
30–40	6.83	180–190	0.25
40–50	6.17	190–200	0.08

[1]Based on data from Baird and Hanson (1998)

The representative depth distribution is consistent with stomach contents analyses which suggest that Dall's porpoises feed high in the water column on vertically migrating mesopelagic species, but occasionally forage on deeper benthic prey (Jefferson 1988; Ohizumi et al. 1998).

2.2.1.7 Family Physeteridae

2.2.1.7.1 *Physeter macrocephalus*, Sperm Whale

The sperm whale has a cosmopolitan distribution, preferring deeper waters seaward of the continental shelf edge (Whitehead 2002). Females and immature males tend to inhabit tropical and temperate waters below 40° latitude, while maturing and adult males move to higher latitudes, occurring in polar waters as adults (Whitehead 2002). Sperm whales feed on cephalopod species, primarily squid, as well as mesopelagic and demersal fish and occasionally crustaceans (Fiscus et al. 1989; Flinn et al. 2002; Kawakami 1980; Martin and Clarke 1986).

To account for published differences in the foraging dive behavior of whales in different regions, separate depth distributions were generated for the Atlantic Ocean, Gulf of Mexico, and the Pacific Ocean. In general, time spent at depth for the regions is consistent with foraging dives to 800–1,200 m in the Western North Atlantic Ocean (Sivle et al. 2012; Teloni et al. 2008; Watwood et al. 2006), and 400–1,300 m in the Western North Pacific Ocean (Amano and Yoshioka 2003; Aoki et al. 2012; Aoki et al. 2007). Overall, sperm whales typically spend 70–80 percent of their time between 20 and 400 m (Sivle et al. 2012; Teloni et al. 2008). At mid- and low latitudes, females and immature animals undertake stereotypic dives lasting about 45 min and to depths between 400 and 1,200 m (Teloni et al. 2008; Watwood et al. 2006). Off Japan, females and immature sperm whales performed similarly stereotyped dive patterns to 1,400 m, lasting 30–50 min (Aoki et al. 2012). Radically different dive behavior has been observed at high latitudes, where mature males undertake dives lasting up to 60 min and to depths of nearly 1,900 m (Sivle et al. 2012; Teloni et al. 2008).

In order to build a representative depth distribution for sperm whales in the Atlantic Ocean, data from Figure 4 in Sivle et al. (2012), Figure 2 in Teloni et al. (2008), and Figure 2 and raw data from Watwood et al. (2006) were used. Sivle et al. (2012) found that the four tagged sperm whales in their study made regular deep dives to depths of 200–1,500 m, averaging a duration of 25 min, followed by a period of 5–15 min of shallow diving close to the surface. Sivle et al. (2012) found that sperm whales spend 80 percent of their time deeper than 20 m. Teloni et al. (2008) recorded the dives of four male sperm whales. Dive duration was between 6 and 60 min and dives ranged in depth between 14 and 1,860 m, with a median depth of 175 m. Most surfacing events (92 percent) lasted less than 15 min (Teloni et al. 2008). Watwood et al. (2006) reported that for whales in the Atlantic Ocean, Gulf of Mexico, and Ligurian Sea, typical foraging dives lasted 45 min, regardless of location. Data was extracted from the depth profiles given by Sivle et al. (2012) and Teloni et al. (2008). The resulting data were then averaged across the four whales recorded in the Teloni et al. (2008) study. The data from Sivle et al. (2012), Teloni et al. (2008), and Watwood et al. (2006) were then averaged together for the resulting representative depth distribution for sperm whales in the Atlantic Ocean, which is given in Table 2-22.

Table 2-22. Percentage of Time at Depth for the Sperm Whale in the Atlantic Ocean[1]

Depth Bin (m)	% of Time at Depth
0–50	29.25
51–100	19.14
101–150	13.48
151–200	3.33
201–250	2.72
251–300	2.29
301–350	2.35
351–400	1.39
401–450	1.17
451–500	1.03
501–600	2.94
601–700	5.52

Depth Bin (m)	% of Time at Depth
701–800	3.30
801–900	2.93
901–1000	1.83
1001–1100	1.44
1101–1200	1.18
1201–1300	1.38
1301–1400	0.57
1401–1500	0.50
1501–1600	0.49
1601–1700	0.59
1701–1800	1.03
1801–1900	0.15

[1]Based on data from Sivle et al. (2012), Teloni et al. (2008), and Watwood et al. (2006)

For the representative depth distribution of sperm whales in the Gulf of Mexico, data from Watwood et al. (2006) were used. In the Gulf of Mexico, 29 tagged whales spent 28 percent of their time within 10 m of the

surface (Watwood et al. 2006). The data represented in Figure 2 was obtained as raw data from the author, then binned, resulting in the depth distribution for sperm whales in the Gulf of Mexico given in Table 2-23.

Table 2-23. Percentage of Time at Depth for the Sperm Whale in the Gulf of Mexico[1]

Depth Bin (m)	% of Time at Depth	Depth Bin (m)	% of Time at Depth
0–50	35.65	501–550	7.72
51–100	1.89	551–600	7.33
101–150	1.85	601–650	4.74
151–200	1.77	651–700	6.24
201–250	1.78	701–750	3.24
251–300	1.83	751–800	1.08
301–350	2.37	801–850	0.27
351–400	4.41	851–900	0.55
401–450	5.98	901–950	1.38
451–500	8.93	951–1000	0.43

[1]Based on data from Watwood et al. (2006)

To build a representative depth distribution for sperm whales in the Pacific Ocean, data from Aoki et al. (2007) were used. Aoki et al. (2007) tagged four whales off the coast of Japan. The mean dive depth for nighttime was 515 m averaged over the two tag locations; the mean dive depth for the daytime was 749.5 m. While this may suggest a diel diving pattern that follows the availability of prey, the pattern seems to depend largely on location (Aoki et al. 2012). The depth distribution for sperm whales in the Pacific Ocean is given in Table 2-24.

Table 2-24. Percentage of Time at Depth for the Sperm Whale in the Pacific Ocean[1]

Depth Bin (m)	% of Time at Depth
1–50	30.24
51–100	4.77
101–150	3.29
151–200	3.30
201–250	3.13
251–300	2.55
301–350	2.60
351–400	3.60
401–450	5.31
451–500	6.48
501–600	9.76
601–700	6.46
701–800	8.58
801–900	8.38
901–1000	1.26
1001–1100	0.34

[1]Based on data from Aoki et al. (2012)

2.2.1.8 Family Ziphiidae

2.2.1.8.1 *Mesoplodon densirostris*, Blainville's Beaked Whale

Blainville's beaked whales inhabit deep temperate and tropical waters of the world's oceans (Pitman 2002b). Little is known about prey species, but the diet of Blainville's beaked whales includes mesopelagic cephalopods, fish, and crustaceans (Herman et al. 1994; Hickmott 2005; MacLeod et al. 2003a; Mead 1989).

In order to build a representative depth distribution for Blainville's beaked whales, data were acquired from Figures 3a and 3b from Arranz et al. (2011), Figure 6 from Baird et al. (2005b), Figures 3a and 3b from Baird et al. (2006), Figure 1 from Barlow et al. (2013), Digital Acoustic Recording Tag (DTAG) data from Johnson and Aguilar de Soto (2008b) and Johnson and Aguilar de Soto (2008a), DTAG data from Tyack (2010, and Figure 1b from Tyack et al. (2006. Arranz et al (2011) tagged 9 whales to collect acoustic and movement data, looking to study buzz and click behaviors during dives; Figures 3a and 3b show the dive profile of a male Blainville's beaked whale over a period of 17 hours. Baird et al. (2005b) tagged four Blainville's beaked whales, and presented cumulative percentage of time spent at depth for two individuals: an adult female with young calf, the daytime data for a large sub-adult or adult female, and the nighttime data for the same sub-adult or adult female. Different data from that same female whale were used to create another set of dive profiles after a 22.6 hour deployment, as published in Baird et al. (2006). Barlow et al. (2013) used DTAGs to collect acoustic information for beaked whales in an attempt to estimate density and abundance; Figure 1 is a typical dive profile for a tagged whale captured over a 15 hour period. Raw DTAG data for two animals in the Canary Islands, provided by Johnson and Aguilar de Soto (Johnson and Aguilar de Soto 2008a, 2008b), were binned, as well as raw DTAG data from one animal in the Bahamas by Tyack (2010). Tyack et al. (2006) used DTAGs to create a representative dive profile for Blainville's beaked whale in an attempt to study how depth impacts foraging tactics. Data from each source were arranged into 100 m bins, and those bins were averaged together to create a representative depth distribution. The depth distribution for Blainville's beaked whales is given in Table 2-25.

Table 2-25. Percentage of Time at Depth for the Blainville's Beaked Whale[1,2]

Depth Bin (m)	% of Time at Depth
1–100	54.3
100–200	10.2
200–300	3.8
300–400	3.2
400–500	3.7
500–600	3.4
600–700	3.8
700–800	4.2
800–900	4.7
900–1,000	3
1,000–1,100	2.2
1,100–1,200	1.8
1,200–1,300	1.1

Table 2-25. Percentage of Time at Depth for the Blainville's Beaked Whale[1,2] *(Cont'd)*

Depth Bin (m)	% of Time at Depth
1,300–1,400	0.8
1,400–1,500	0.1

[1]Based on data from Arranz et al. (2011), Baird et al.(2005b), Baird et al. (2006), Barlow et al. (2013), Johnson and Aguilar de Soto (Johnson and Aguilar de Soto 2008a, 2008b), Tyack et al. (2006), and Tyack (2010)
[2] This depth distribution is also representative of the Longman's beaked whale, the HSTT beaked whale guild, and the AFTT beaked whale guild

2.2.1.8.2 *Indopacetus pacificus*, Longman's Beaked Whale

Longman's beaked whales inhabit generally warm, deep, pelagic waters of tropical and subtropical regions. Little is known about the Longman's beaked whale feeding behaviors. Similar to other beaked whales who dive deep to forage for food, their diet most likely consists primarily of cephalopods (Yamada 2002).

Little data have been collected on the dive behavior of the Longman's beaked whale. The existence of Longman's beaked whales had previously only been known from the skeletal remains of stranded animals (Moore 1972; Pitman 2002a); however, some live sightings have been recognized as this species (Dalebout et al. 2003; Pitman et al. 1999). Dive times have been found to last from 11 to 33 min, although one dive may have been over 45 min (Anderson et al. 2006; Gallo-Reynoso and Figueroa-Carranza 1995).

Due to the lack of available data on the diving behavior of the Longman's beaked whale, it will be represented by a surrogate species: the Blainville's beaked whale (Section 0). Though originally placed in the *Mesoplodon* genus, differences in features of the skull have led to the reclassification of this species into its own genus, *Indopacetus*; the previous classification into the same genus, and the current classification into the same family, is the primary reason for using Blainville's beaked whale as the surrogate species. The depth distribution for the Longman's beaked whale can be found in Table 2-25.

2.2.1.8.3 HSTT Beaked Whale Guild, *Mesoplodon* spp.

Within the Southern California portion of the HSTT Study Area, a beaked whale guild has been established. This guild was created to account for the difficulties associated with identifying beaked whales to the species level at sea. The beaked whale guild includes: Blainville's beaked whale, Ginkgo-toothed beaked whale (*Mesoplodon ginkgodens*), Stejneger's beaked whale (*Mesoplodon stejnegeri*), Hubb's beaked whale (*Mesoplodon carlshubbi*), Perrin's beaked whale (*Mesoplodon perrini*), and pygmy beaked whale (*Mesoplodon peruvianus*). The depth distribution used for this group is that of the Blainville's beaked whale. The depth distribution for the beaked whale guild in the HSTT Study Area can be found in Table 2-25.

2.2.1.8.4 AFTT Beaked Whale Guild

Within the AFTT Study Area, all beaked whales are represented as one group due to the difficulty of identifying beaked whales at sea to the individual species level. The AFTT beaked whale guild is a composite of all species that would be present in the Study Area; including Cuvier's beaked whale (*Ziphius cavirostris)*, Blainville's beaked whale, Sowerby's beaked whale (*Mesoplodon bidens*), Gervais' beaked whale (*Mesoplodon europaeus*), and True's beaked whale (*Mesoplodon mirus*). While both Blainville's and Cuvier's beaked whales are both located within the AFTT Study Area, the depth distribution for Blainville's beaked whales (Section 2.2.1.9.1) was used as the representative species for this group. Blainville's beaked whales

spend a greater percentage of time in the upper 100 m of water than Cuvier's, making the model a more conservative estimate of affected beaked whales. The depth distribution of beaked whales in the AFTT study area can be found in Table 2-25.

2.2.1.8.5 *Ziphius cavirostris*, Cuvier's Beaked Whale

Cuvier's beaked whales inhabit slope waters with steep gradients around the world's oceans, with the exception of the high polar seas (Heyning 1989). Stomach contents analyses indicate that prey species include mesopelagic and benthic cephalopods, fish, and crustaceans (Heyning 1989; Hickmott 2005; Santos et al. 2001a). It appears however, that Cuvier's beaked whales eat mostly squid, and the majority of prey are open-ocean species that occur well below the surface, including on or near the seafloor in deep waters (Reeves et al. 2002).

In order to build a representative depth distribution for the Cuvier's beaked whale (Table 2-26), data from Figure 1 from Aguilar de Soto et al. (2006), Figures 5 from Baird et al. (2005b), Figure 3c from Baird et al. (2006), Figure 2a from Baird et al. (2008), Figure 1 from Barlow et al. (2013), DTAG data from Johnson and Sturlese (Johnson and Sturlese 2008a, 2008b), Figure 1a from Kvadsheim et al. (2012), and Figures 2a and 3a from Schorr et al. (2014). Aguilar de Soto et al. (2006) presented a time-depth profile of a Cuvier's beaked whale off Italy over a 15.6 hour period. Baird et al. (2005b) presented the cumulative percentage of time spent at depth for an adult female during the day and at night. Similarly, Baird et al. (2008) looked at diel variation in Cuvier's beaked whale diving behavior, presenting the cumulative percentage of time spent at depth for two tagged whales during both the day and night. Barlow et al. (Barlow et al. 2013) used DTAGs to collect acoustic information for beaked whales in an attempt to estimate density and abundance; Figure 1 is a typical dive profile for a tagged whale captured over a 15 hour period. Raw DTAG data collected on multiple occasions for an animal in Liguria, Italy, provided by Johnson and Sturlese (Johnson and Sturlese 2008a, 2008b), were binned. Kvadsheim et al. (2012) presented changes in dive behavior in response to sonar; as this report is portraying normal Cuvier's beaked whale behavior, the portion of the dive profile provided by Kvadsheim et al. (2012) in which sonar was used has been omitted from the typical depth distribution calculated. Schorr et al. (2014) provided multi-day tag data for Cuvier's beaked whales, allowing for observation of diel patterns in dive behavior. The depth distributions from these studies were averaged together to create the representative depth distribution below. The depth distribution for Cuvier's beaked whales is given in Table 2-26.

Table 2-26. Percentage of Time at Depth for Cuvier's Beaked Whale[1,2]

Depth Bin (m)	% of Time at Depth
0–100	31.9
100–200	10.3
200–300	11.7
300–400	5.5
400–500	4.1
500–600	3.9
600–700	5.1
700–800	4.1
800–900	3.4
900–1,000	4.8
1,000–1,100	4.3
1,100–1,200	3.3

Table 2-26. Percentage of Time at Depth for Cuvier's Beaked Whale[1,2] (Cont'd)

Depth Bin (m)	% of Time at Depth
1,200–1,300	2.2
1,300–1,400	1.4
1,400–1,500	1.1
1,500–1,600	0.3
1,600–1,700	0.9
1,700–1,800	0.5
1,800–1,900	0.8

[1]Based on data from Aguilar de Soto et al. (2006), Baird et al. (2005b), Baird et al. (2006), Baird et al. (2008), Barlow et al. (2013), Johnson and Sturlese (Johnson and Sturlese 2008a, 2008b), Kvadsheim et al. (2012), and Schorr et al. (2014)
[2]This depth distribution is also representative of the Baird's beaked whale and the Northern bottlenose whale

This representative depth distribution is consistent with foraging dives from 689 to 1,888 m in the Mediterranean Sea (Tyack et al. 2006) and to 1,450 m off Hawaii (Baird et al. 2006). Based on the representative depth distribution in Table 2-26, Cuvier's beaked whales spent 31.9 percent of their time between 0–100 m and 36.1 percent of time deeper than 500 m; these values remain consistent with the data reported by Baird et al. (2008), in which Cuvier's beaked whales spend 12.4–51.1 percent of their time spent at depths less than 50 m, and between 33.9–52.1 percent of time at depths greater than 500 m.

2.2.1.8.6 *Berardius bairdii*, Baird's Beaked Whale

Baird's beaked whales inhabit temperate waters of the North Pacific Ocean and adjoining seas, primarily in the deep waters offshore of the continental shelf (Balcomb 1989; Kasuya 1986). This species consumes benthic and epibenthic fish and cephalopods, and occasionally feeds on mesopelagic species as well (Balcomb 1989; Kasuya 2002; Walker et al. 2002).

Little data have been collected on the dive behavior of Baird's beaked whales. Stomach contents analysis suggests that whales are feeding at depths of 800–1,200 m off Japan, feeding on prey at or near the seafloor (Reeves et al. 2002; Walker et al. 2002). Minamaka (2007) reported that one animal carrying a time-depth recorder dove down to a maximum depth 1,777 m, with dives lasting up to 64.4 min, which is similar to the maximum dive duration of 67 min observed by Kasuya (1986). The maximum dive depth reported by the first deployment of a multi-sensor tag on this species was given as roughly 1400 m (Stimpert et al. 2014).

Due to the lack of data on the diving behavior of the Baird's beaked whale, it will be represented by a surrogate species: Cuvier's beaked whale (Section 2.2.1.9.5). The Cuvier's beaked whale is also a member of the subfamily Ziphiidae, and the feeding habits and types of prey for the two species are similar. The diving pattern of Baird's beaked whales appears very similar to other beaked whales, in which a long duration, deep dive is followed by shorter duration, shallow dives (Minamikawa et al. 2007; Tyack et al. 2006). The depth distribution for the Baird's beaked whale can be found in Table 2-26.

2.2.1.8.7 *Hyperoodon ampullatus,* Northern Bottlenose Whale

Northern bottlenose whales are found in deep, cold temperate and subpolar waters of the North Atlantic Ocean (Gowans 2002). The primary prey of bottlenose whales is squid, principally those species of the genus *Gonatus* (Hooker et al. 2001; Santos et al. 2001b). They also eat herring, various deep sea fish, shrimp, and sometimes sea cucumbers and starfish (Reeves et al. 2002).

Little data have been collected on the dive behavior of Northern bottlenose whales. Hooker and Baird (1999) reported on the diving behavior of two individuals from Canadian waters. Both individuals routinely dove deeper than 800 m, reaching a maximum dive depth of 1,453 m.

Due to the lack of available data on the diving behavior of the Northern bottlenose whale, it will be represented by a surrogate species: the Cuvier's beaked whale (Section 2.2.1.9.5). Cuvier's beaked whales are also deep-diving members of the family Ziphiidae, and are of similar size to female Northern bottlenose whales (Leatherwood and Reeves 1983). Additionally, the primary prey for the Northern bottlenose whale is squid, as is the primary prey for Cuvier's beaked whales. The depth distribution for the Northern bottlenose whale can be found in Table 2-26.

2.2.2 Carnivores

2.2.2.1 Family Otariidae

2.2.2.1.1 *Arctocephalus townsendi*, Guadalupe Fur Seal

The Guadalupe fur seal breeds at only two rookery locations: the east side of Isla Guadalupe and the southeast side of Isla Bonito del Este (Maravilla-Chavez and Lowry 1999). Single animals have occasionally been seen at islands along the coast of Baja California and California (Stewart et al. 1987). Squid, teleost fish, and crustaceans comprise the diet of the Guadalupe fur seal (Aurioles-Gamboa and Camacho-Ríos 2007; Belcher and Lee 2002; Riedman 1990).

Little data have been collected on the dive behavior of Guadalupe fur seals. In order to build a representative depth distribution for Guadalupe fur seals, data from Figure 2 in Lander et al. (2000) were used. Lander et al. (2000) obtained information on the diving behavior of Guadalupe fur seals by satellite tagging a single female following rehabilitation off southern California. Most dives were performed at night and lasted 2–4 min (mean dive time of 1.7 min, SD=1.0 min), with a maximum dive duration of 18 min (Lander et al. 2000). The mean dive depth was 15.7 m (SD=11.8 m). The maximum recorded dive depth was 130 m, although most dives were less than 20 m deep. While Lander et al. (2000) reported only the number of dives to various depth bins, this is used as a proxy for the time spent at depth. The bins over 40 m were presented together as they represented a small percentage of time at depth. The depth distribution for Guadalupe fur seals is given in Table 2-27.

Table 2-27. Percentage of Time at Depth for the Guadalupe Fur Seal[1]

Depth Bin (m)	% of Time at Depth
0–20	92.0
20–40	7.0
40–160	1.0

[1]Based on data from Lander et al. (2000)

Data from Gallo-Reynoso et al. (2008) also studied the diving behavior of one adult female, finding a mean dive depth of 17 m (SD=10 m) with an average dive duration of 2.6 min (SD=1.4 min).

2.2.2.1.2 *Callorhinus ursinus*, Northern Fur Seal

Northern fur seals occupy the pelagic waters of the North Pacific Ocean, Bering Sea, and Sea of Japan, ranging coastally as far south as Baja California, Mexico and Japan, and with an at-sea southern limit around 35°N (Gelatt and Lowry 2008). Northern fur seals are known to feed in the deep waters along the continental shelf break, as well as shallower waters of the shelf itself (Gentry 2002; Ponganis et al. 1992). The diet of northern fur seals varies regionally and seasonally, but is comprised principally of finfish (e.g., Pacific herring, sand lance, capelin, myctophids) and squid; they will occasionally feed upon other prey such as birds and crustaceans (Ream et al. 2005; Riedman and Estes 1990).

In order to build a representative depth distribution for the Northern fur seals, data from Table 1 in Kooyman et al. (1976) were used. The dive behavior and physiology of the northern fur seal was among the earliest pinniped species to be tagged and tracked (Kooyman et al. 1976). Table 1 indicates the number of dives to specific depth bins; thus this data from Kooyman et al. (1976) will be used as a proxy for percentage of time spent at depth. Kooyman et al. (1976) found that shallow dives (0–20 m) lasted less than 1 min in duration. Deeper dives, from 20–140 m, lasted from 2–5 min. The maximum dive depth in this study was 190 m. The average interval between dives was 17 min. The depth distribution for Northern fur seals is given in Table 2-28.

Table 2-28. Percentage of Time at Depth for the Northern Fur Seal[1]

Depth Bin (m)	% of Time at Depth
0–20	48.36
20–50	42.32
50–80	5.94
80–110	0.96
110–140	1.99
140–170	0.39
170–200	0.04

[1]Based on data from Kooyman et al. (1976)

While other studies did not include depth distributions for northern fur seals, they did provide additional information to categorize dive behavior. Because northern fur seals spend the vast majority of their lives at sea (87–90 percent of the year), only coming ashore to breed for 35–45 days from June to August, most of the tagging studies examine the dive behavior of females on excursions from breeding colonies in the Bering Sea (Baker 2007; Baker and Donohue 2000; Gentry 2002; Goebel et al. 1991; Kooyman et al. 1976; Kuhn et al. 2009; Ream et al. 2005). In general, adult females on foraging excursions generally follow one of three dive profiles: shallow, deep, or mixed depth. Shallow-diving seals show a crepuscular pattern with dive depths varying according to movement of the deep scattering layer. Deep-diving seals show no temporal pattern, apparently ignoring the diel movements of vertically migrating prey, and have no consistent change in depth within bouts. Mixed-depth divers alternate between dive profiles, perhaps shifting prey types (Gentry et al. 1986). Female northern fur seals dive mostly at night (68 percent) (Gentry et al. 1986). Individuals may be consistent in their diving behavior, presumably choosing prey sources at different depths, as evidenced by unique fatty acid profiles specific to a differentiated prey type (deep versus vertically migrating species, for example); however, other evidence points towards a seasonal shift in dive behavior (Gentry 2002; Gentry et al. 1986; Hobson and Sease 1998; Hobson et al. 1997). Radio-tracking studies suggest that deep-diving patterns are used while foraging on the continental shelf, while shallow-diving patterns occur over deeper waters off the shelf break or in the Aleutian Basin (Gentry et al. 1986; Goebel et al. 1991).

Female northern fur seals have been recorded diving to a maximum depth of 256 m (Ponganis et al. 1992), although they most frequently dive between 50 and 60 m (Gentry et al. 1986). The activity budgets for adult females on foraging trips was 17 percent of time spent resting, 26 percent of time spent diving, and 57 percent of time spent in surface active time (Gentry et al. 1986).

Male northern fur seal diving behavior has also been examined (Sterling and Ream 2004) and has revealed that like parturient females, juvenile males exhibit shallow versus deep dive patterns based upon foraging location (deep dives in water less than 200 m deep, shallow nighttime dives in waters up to 3,000 m deep). In a study of 19 juvenile male northern fur seals on foraging excursions during the breeding season in the Bering Sea, the maximum recorded dive depth was 175 m, with a mean dive depth of 17.5 m (SD=1.5 m) (Sterling and Ream 2004).

2.2.2.1.3 *Zalophus californianus*, California Sea Lion

California sea lions primarily breed on island beaches off southern California, along Baja California, Mexico, and in the Gulf of California (Heath 2002). They eat a variety of prey, including schooling fish, crustaceans, and cephalopods (García-Rodríguez and Aurioles-Gamboa 2004; Melin et al. 2008; Porras-Peters et al. 2008). California sea lions often make shallow dives in some coastal areas for epipelagic prey, and deeper dives in others, such as the Gulf of California, for mesopelagic prey (Costa et al. 2004; Lowry and Carretta 1999; Melin and DeLong 1999).

In order to build a representative depth distribution for California sea lions, data from Figure 4 in Feldkamp et al. (1989) and Figure 1a in Weise (2006) were used. Both Figures show the number of dives to specific depth bins, thus the data from Feldkamp et al. (1989) and Weise (2006) will be used as a proxy for percentage of time spent at depth. Because data indicate differences in diving behavior of males (Weise 2006) and females (Feldkamp et al. 1989; Kuhn 2006; Melin et al. 2008), data from Weise (2006) and Feldkamp et al. (1989) were averaged to create a composite distribution. Weise (2006) reported an average dive depth of 32 m, but that most dives occurred within the depth range of 10 to 20 m. Feldkamp et al. (1989) found that the maximum dive depth for females was roughly 274 m. The mean depths ranged from 31 to 98 m, but the majority of dives went to between 20 and 50 m. In order to account for the time spent at the surface, an activity budget from Table 3 in Thomas et al. (2010) was used, incorporating both male and female sea lions. Based on these numbers, a percent time swimming at the surface (63.62 percent) was added into the average taken from the Feldkamp et al. (1989) and Weise (2006) data. The remaining averages from both studies were redistributed proportionally to account for the remaining 36.38 percent of time. The resulting depth distribution profile includes data from all three studies. The depth distribution for California sea lions is given in Table 2-29.

Table 2-29. Percentage of Time at Depth for the California Sea Lion[1]

Depth Bin (m)	% of Time at Depth
0–10	68.39
10–20	5.92
20–30	6.01
30–40	4.86
40–50	4.00
50–60	2.31
60–70	1.49
70–80	1.02

Depth Bin (m)	% of Time at Depth
120–130	0.56
130–140	0.40
140–150	0.46
150–160	0.53
160–170	0.46
170–180	0.33
180–190	0.15
190–200	0.13

Table 2-29. Percentage of Time at Depth for the California Sea Lion[1] (Cont'd)

Depth Bin (m)	% of Time at Depth	Depth Bin (m)	% of Time at Depth
80–90	0.75	200–210	0.22
90–100	0.69	210–220	0.11
100–110	0.73	220–230	0.05
110–120	0.60	230–500	0.22

[1]Based on data from Feldkamp et al. (1989), Weise (2006), and Thomas (2010)

While other studies did not include usable depth distributions for California sea lions, they did provide additional information to categorize dive behavior. Mean dive depths reported for female California sea lions range from 45–70 m with maximum dive depths ranging from 104–279 m (Kuhn 2004; Kuhn 2006; Melin et al. 2008). While this data set does not necessarily capture the maximum dive depths reported in several locations (greater than 200 m) (Costa et al. 2004; Feldkamp et al. 1989; Kuhn 2004; Kuhn 2006; Melin et al. 2008), the depth distribution is consistent with studies by Kuhn (2004) and Melin (2008), both of whom demonstrated that the majority of dives (ranging from 55–85 percent) were less than 50 m deep. Similarly, Melin and DeLong (1999) reported that most dives were shallower than 100 m. Therefore, although the depth distribution in Table 2-28 may be shallower than seen in some locations, it does capture published diving behavior for the species, and is representative for California sea lions.

2.2.2.2.Family Phocidae

2.2.2.2.1 *Cystophora cristata*, Hooded Seal

Hooded seals typically inhabit continental shelf and slope waters of the North Atlantic Ocean. Adults feed on commercial-size fish such as capelin, cod, and redfish, as well as squid and amphipods (Bjørke 2001; Haug et al. 2004; Hauksson and Bogason 1997).

In order to build a representative depth distribution for hooded seals, both the text and data from Figures 2A-L in Folkow and Blix (1999) were used. Folkow and Blix (1999) reported tag data from 16 seals from the Greenland Sea. The seals had an average submersion time of 77 percent. While not an estimate of time spent at depth, it is the closest approximation to a depth distribution in the published literature. Due to the lack of data on time spent at depth, the data from Folkow and Blix (1999) will be used as a proxy for percentage of time spent at depth. Assuming a submersion time of 77 percent gives us a remaining surface time of 23 percent, which has been included as the 0–1 m bin below. The remaining distribution bins were taken from the data in the text of Folkow and Blix (1999), which is also displayed in Figures 2A through 2L. The remaining bins from the Folkow and Blix (1999) depth distribution were redistributed proportionally to account for the remaining 77.0 percent of time. The depth distribution for hooded seals is given in Table 2-30.

Table 2-30. Percentage of Time at Depth for the Hooded Seal[1]

Depth Bin (m)	% of Time at Depth
0–1	23
1–52	13.09
52–100	6.16
100–600	54.67

Table 2-30. Percentage of Time at Depth for the Hooded Seal[1] (Cont'd)

Depth Bin (m)	% of Time at Depth
600–968	1.925
968–1,016	1.155

[1]Based on data from Folkow and Blix (1999)

While other studies did not include usable depth distributions for hooded seals, they did provide additional information to categorize dive behavior. Bajzak et al. (2009) reported dive depths for post-breeding seals consistent with those from Folkow and Blix (1999), although the seals dove to shallower depths during the molting period. Seals from the Gulf of St. Lawrence spent a similar percentage of their time diving, but considerably less during the molting period (Bajzak et al. 2009). However, the depth distribution in from Folkow and Blix (1999) represents dive depths from seals in waters of different depths; therefore this depth distribution represents the best representative depth distribution.

2.2.2.2.2 *Monachus schauinslandi*, Hawaiian Monk Seal

The range of the Hawaiian monk seal is limited to the central Pacific Ocean, with breeding colonies principally in the northwestern Hawaiian Islands (Gilmartin and Forcada 2002; Johanos and Baker 2002). Hawaiian monk seals primarily consume benthic prey; stomach contents and scat analyses indicate that prey constitute both diurnal and nocturnal species. Reef associated fish and octopus compose a large portion of the diet (DeLong et al. 1984; Goodman-Lowe 1998; Kenyon and Rice 1959). Most seals focus foraging efforts in the top 100 m of the water column, although some seals dive to greater than 300 m deep (Parrish et al. 2002; Parrish et al. 2000; Parrish et al. 2005; Stewart et al. 2006).

In order to build a representative depth distribution for Hawaiian monk seals, data from two Stewart and Yochem (2004a, 2004b) studies were used. Figure 25 from Stewart and Yochem (2004a) and Figure 40 from (2004b) provided time at depth for weaned pups, juveniles, and adults that could be averaged for a representative depth distribution. Stewart and Yochem (2004a, 2004b) presented depth distributions for 18 animals from Kure Atoll and Laysan Island, respectively. The maximum dive depth reported was greater than the recording limit of the tag at 490 m, therefore, 500 m is used as a conservative maximum dive depth. Most dives of all seals were shallower than 40 m and lasted less than 6–8 min (Stewart and Yochem 2004a, 2004b). The depth distribution for Hawaiian monk seals is given in Table 2-31.

Table 2-31. Percentage of Time at Depth for the Hawaiian Monk Seal[1]

Depth Bin (m)	% of Time at Depth
0–4	33.0
4–20	34.68
20–40	13.2
40–60	5.45
60–80	3.58
80–100	2.08
100–120	2.53
120–140	2.0
140–160	0.75
160–180	0.69
180–200	0.25

Table 2-31. Percentage of Time at Depth for the Hawaiian Monk Seal[1] (Cont'd)

Depth Bin (m)	% of Time at Depth
200–250	0.38
250–350	0.88
350–500	0.56

[1]Based on data from Stewart and Yochem (2004a, 2004b)

While other studies did not include usable depth distributions for Hawaiian monk seals, they did provide additional information to categorize dive behavior. In the representative depth distribution above, 92 percent of the monk seals' time is spent within the top 100 m. This is consistent with previous studies that have demonstrated Hawaiian monk seal foraging occurring at shallow reef sites (DeLong et al. 1984; Littnan et al. 2004; Parrish et al. 2000; Schlexer 1984).

2.2.2.2.3 *Mirounga angustirostris*, Northern Elephant Seal

Northern elephant seals are limited to the North Pacific Ocean, with breeding haul outs located along the western coast of North America from northern California to Baja California, Mexico. Seals utilize deep waters for foraging, traveling north and west from breeding beaches, and traveling as far north as the Gulf of Alaska and Aleutian Islands (Hindell 2002). Elephant seals feed primarily on vertically migrating epipelagic and mesopelagic squid, but eat a variety of prey species, including elasmobranchs, crustaceans, cephalopods, and fish (DeLong and Stewart 1991; Sinclair 1994; Stewart and Huber 1993).

In order to build a representative depth distribution for Northern elephant seals, data from DeLong and Stewart (1991), Hakoyama et al. (1994), Le Boeuf et al. (1986), and Naito et al. (1989) were used. In addition, a surface time from DeLong and Stewart (1991) was incorporated into the data. The text of DeLong and Stewart (1991) states that Northern elephant seals are submerged 86 percent of the time, leaving an above-surface time percentage of 14 percent (DeLong and Stewart 1991). Due to the lack of data on time spent at depth, the data from these sources, citing percentage of dives to specific depth bins will be used as a proxy for percentage of time spent at depth. As the data show sex differences in foraging and diving behavior (DeLong and Stewart 1991; Hakoyama et al. 1994; Le Boeuf et al. 1986; Le Boeuf et al. 1993; Naito et al. 1989), males and females were averaged together to create a representative depth distribution. In males, the data averaged from Figure 1 in Delong and Stewart (1991) and Figure 4 in Hakoyama et al. (1994) showed that 83 percent of dives took place between the surface to 500 m, most frequently occurring from 300–500 m. In females, the data averaged from Figure 1 in Le Boeuf et al. (1986), Figure 2 in Naito et al. (1989), and Figure 4 in Hakoyama et al. (1994), showed that 85 percent of dives were to depths of 300–700 m, most frequently from 400–600 m. For males, dives deeper than 500 m were unusual, whereas dives over 700 m were rare for females (DeLong and Stewart 1991; Hakoyama et al. 1994; Le Boeuf et al. 1988; Le Boeuf et al. 1986; Naito et al. 1989). Data from each Figure were summed into 100 m bins and averaged together. The remaining bins of each study were averaged and redistributed proportionally to account for the remaining 86 percent of non-surface time. The resulting depth distribution profile includes data from all studies. The depth distribution for Northern elephant seals is given in Table 2-32.

Table 2-32. Percentage of Time at Depth for the Northern Elephant Seal[1]

Depth Bin (m)	% of Time at Depth
0–100	21.4

Table 2-32. Percentage of Time at Depth for the Northern Elephant Seal[1] (Cont'd)

Depth Bin (m)	% of Time at Depth
100–200	7.65
200–300	8.86
300–400	13.42
400–500	18.06
500–600	16.34
600–700	9.98
700–800	2.15
800–900	0.77
900–1000	0.52
1,000–1,100	0.52
1,100–1,200	0.43

[1]Based on data from DeLong and Stewart (1991), Hakoyama et al. (1994), Le Boeuf et al. (1986), and Naito et al. (1989)

While other studies did not include usable depth distributions for northern elephant seals, they did provide additional information to categorize dive behavior. Robinson et al. (2012) found that the dive depths of most seals showed a clear diel pattern, consistent with targeting vertically migrating prey species. Robinson et al. (2012) found the mean dive depth to be 516 m and a mean dive duration of 23.1 min. Active-bottom dives made up the greatest percentage of dives (54.0 percent) in this study (Robinson et al. 2012). Maximum dive depths for elephant seals covered a wide range of depths, from under 1,000 m (Crocker et al. 2006; Davis et al. 2001; Davis and Weihs 2007; Le Boeuf et al. 1988) to the deepest dive ever recorded by an elephant seal at 1,747 m (Robinson et al. 2012).

2.2.2.2.4 *Halichoerus grypus*, Grey Seal

Grey seals are found in temperate, coastal waters of the North Atlantic Ocean. Grey seals feed on both pelagic (herring and sand lance) and benthic (flatfish) prey (Bowen et al. 1993; Iverson et al. 2004).

In order to build a representative depth distribution for grey seals, data from the text of Harvey et al. (2008), a maximum dive depth from Beck et al. (2003), as well as an activity budget from Thomson et al. (1991), were used. Harvey et al. (2008) presented a distribution of maximum dive depths for a range of age, sex, and seasonal classes, which, while not an exact representation of time spent in each depth range, is a good approximation as grey seals are primarily shallow divers. Due to the lack of data on time spent at depth, the data from Harvey et al. (2008) will be used as a proxy for percentage of time spent at depth. However, the data from Harvey et al. (2008) only consider when the animal is beneath the surface. Thompson et al. (1991) tracked three swimming juvenile grey seals and reported that across three behavioral states (traveling, short trips, and resting), animals spent on average 84.1 percent of their time submerged. Therefore, the average time spent at the surface from Thompson et al. (1991) was combined with the dive distribution data from Harvey et al. (2008) to generate an estimate of the depth distribution for the grey seal. The maximum dive depth of 412 m reported by Beck et al. (2003) is used as the maximum depth. The depth distribution for gray seals is given in Table 2-33.

Table 2-33. Percentage of Time at Depth for the Grey Seal[1]

Depth Bin (m)	% of Time at Depth
0–40	81.7

Table 2-33. Percentage of Time at Depth for the Grey Seal[1] (Cont'd)

Depth Bin (m)	% of Time at Depth
40–100	14.2
100–200	3.3
200–412	0.8

[1]Based on data from Harvey et al. (2008), Beck et al. (2003), and Thompson et al. (1991)

While other studies did not include usable depth distributions for grey seals, they did provide additional information to categorize dive behavior. Beck et al. (2003) reported that 73.9 percent and 59.4 percent of dives were in the top 60 m during the day and night, respectively, and that 95.9 percent of dives were in the top 120 m. Lidgard et al. (2003) found that 41 percent of dives were within 10 m of the surface.

2.2.2.2.5 *Phoca vitulina*, Harbor Seal

Harbor seals are found in shallow inshore and coastal waters of the Northern Hemisphere (Burns 2002). Prey species include epibenthic and benthic fish (e.g., sandlance, flounder, and herring) and squid (Brown and Mate 1983; Olesiuk 1993; Payne and Selzer 1989).

In order to build a representative depth distribution for harbor seals, data from Table 3 in Womble et al. (2014) and an activity budget from Bowen et al. (1999) were used. Womble et al. (2014) studied the dive behavior of 12 female harbor seals in Alaska. Table 3 shows the percentage of dives to specific depth bins; thus, this data from Womble et al. (2014) will be used as a proxy for percentage of time spent at depth. Seals in this study were found to dive most frequently (81.6 percent) to depths shallower than 50 m. It should be noted that this study cites the percentage of dives to certain depths, as opposed to the percentage of time spent in each depth bin, including time spent in that bin on the way to a deeper bin. However, the Womble et al. (2014) data are the best available estimate of time spent at depth. The activity budget from Bowen et al. (1999) provided a surface time of 85.01 percent. The remaining bins from Womble et al. (2014) were redistributed proportionally to account for the remaining 14.99 percent of non-surface time. The resulting depth distribution profile includes data from both studies. The depth distribution for harbor seals is given in Table 2-34.

Table 2-34. Percentage of Time at Depth for the Harbor Seal in the HSTT Study Area[1]

Depth Bin (m)	% of Time at Depth
0-4	85.01
4–50	12.22
50–100	2.32
100–150	0.37
150–200	0.05
200–250	0.01
250–300	0

[1]Based on data from Womble et al. (2014) and Bowen et al. (1999)

While other studies did not include usable depth distributions for harbor seals, they did provide additional information to categorize dive behavior. Gjertz et al. (2001) reported the maximum depth reached by harbor seals to be within the 200–350 m range, however, additional studies have reported shallower maximum dive depths, reaching less than 100 m off Nova Scotia (Bowen et al. 1999) , Svalbard (Jorgensen et al. 2001), and in

Prince William sound (Frost et al. 2001). Hastings et al. (2004) observed that less than six percent of harbor seals dive to depths greater than 100 m, although one seal dove to 508 m (Hastings et al. 2004). Harbor seals near Svalbard, Norway, dove to a maximum depth of 452 m, although 50 percent of dives were shallower than 40 m, and 95 percent were to less than 250 m (Gjertz et al. 2001). Eguchi and Harvey (2005) observed that males dive deeper than females, with males diving to depths shallower than 154 m and females diving to depths shallower than 76 m 95 percent of the time.

2.2.2.2.6 Seal Guild in the AFTT Study Area

Within the AFTT Study Area, seals are often difficult to distinguish when viewing at sea. Many surveyed species are listed as "unidentified." Therefore, the density data from these surveys have been combined for the two most abundant species of seals in the AFTT Study Area, grey seals (Section 2.2.2.2.4) and harbor seals (Section 2.2.2.2.5). As a result, the depth distributions for the two species from Table 2-33 and Table 2-34 were averaged together using the source data from Womble et al. (2014), Harvey et al. (2008), Beck et al. (2003), Bowen et al. (1999) and Thomson et al. (1991) in order to average these two species together to create a representative depth distribution for seals in the AFTT Study Area. While the surface bin for harbor seals (0–50 m) was slightly larger than the surface bin for gray seals (0–40 m), they were averaged together to create a composite depth distribution for these two species. The resulting representative depth distribution for seals in the AFTT Study Area is given in table 2-35.

Table 2-35. Percentage of Time at Depth for Seals in the AFTT Study Area[1]

Depth Bin (m)	% of Time at Depth
0–50	89.47
50–100	8.26
100–200	1.86
200–412	0.41

[1]Based on Womble et al. (2014), Harvey et al. (2008), Beck et al. (2003), Bowen et al. (1999), and Thomson et al. (1991)

2.2.2.2.7 *Pagophilus groenlandicus*, Harp Seal

Harp seals are found in ice-associated waters of the Arctic (Lavigne 2002). Harp seals forage on a variety of prey, including Arctic cod and capelin, amphipods, and krill (Haug et al. 2004; Lawson et al. 1998; Nilssen et al. 2001).

Given the characteristic shallow diving pattern in the post-breeding to post-molting period (spring), two depth distributions are given in Table 2-36 for the harp seal. Folkow et al. (2004) characterized diving behavior of 16 adult harp seals throughout the year in two different years. In order to build a representative depth distribution for harp seals during the breeding and molting season, data from Figure 5A in Folkow et al. (2004) were used. In order to build a representative depth distribution for harp seals during the remainder of the year, data from Figure 7C of Folkow et al. (2004) were used. This study reported that after the period of time close to the ice edge, the seals then moved into deeper water in the open ocean, diving up to 492 m and 568 m in the different years. While close to the ice edge during the breeding and molting season in summer, seals spent most of their time in shallow depths, with 70-90 percent of their diving time spent in the top 50 m of the water column (Folkow et al. 2004). A large proportion of the seals (9 out of a total of 14; both years) at some time dove deeper than 450 m, and dives deeper than 300 m represented greater than 12 percent of all dives. There were significant seasonal variations in diving depths, with dives being significantly

shallower in spring/summer than in autumn and winter (Folkow et al. 2004). The depth distribution for harp seals is given in Table 2-36.

Table 2-36. Percentage of Time at Depth for the Harp Seal[1]

Depth Bin (m)	% of Time at Depth	
	Post-breeding to Post-molting (Spring)	Remainder of Year (Summer, Winter, Fall)
0–20	52	32
20–50	29	17
50–100	12	16
100–200	5	18
200–300	2	11
300–400	0	5
400–492	0	1

[1]Based on data from Folkow (2004)

While other studies did not include usable depth distributions for harp seals, they did provide additional information to categorize dive behavior. Lyderson and Kovacs (1993) found that lactating females had maximum dive depths of 90 m, which is consistent with the majority of seals in the data above. Pacific cod, one of the dominant prey types found in seals feeding offshore, inhabit the top 300 m of the water column, consistent with the diving depths in Table 2-36 (Wathne et al. 2000).

2.2.2.2.8 *Phoca hispida*, Ringed Seal

Ringed seals have a circumpolar distribution within Arctic waters. Primary prey species include arctic cod, amphipods, and crustaceans (Labansen et al. 2007; Wathne et al. 2000).

In order to build a representative depth distribution for ringed seals, data from Figure 3 in Gjertz et al. (2000) were used, along with a surface bin taken from Lydersen (1991). Gjertz et al. (2000) reported the percentage of dives to different depths for seven ringed seals. This data from Gjertz et al. (2000) will be used as a proxy for percentage of time spent at depth. Gjertz et al. (2000) found that 48 percent of all dives were shallower than 20 m and 90 percent of dives were shallower than 100 m. Because percentage of time spent at the surface was not calculated in Gjertz et al. (2000), the Lydersen data (1991) were used to estimate this time. The Lydersen (1991) data are from a single female ringed seal over a six day period. If the percentage of time at the surface (30.3 percent) from Lydersen (1991) is used as an estimate, and the percentage of dives taken as a proxy for the percentage of time, then the following representative depth distribution results. The remaining bins of the Gjertz study were redistributed proportionally to account for the remaining 69.7 percent of non-surface time. The resulting depth distribution profile includes data from both studies. The depth distribution for ringed seals is given in Table 2-37.

Table 2-37. Percentage of Time at Depth for the Ringed Seal[1]

Depth Bin (m)	% of Time at Depth
0–1	30.3
1–4	9.76
4–8	13.24
8–12	5.23

Depth Bin (m)	% of Time at Depth
30–40	4.88
40–50	4.18
50–100	14.64
100–150	5.58

Table 2-37. Percentage of Time at Depth for the Ringed Seal[1] (Cont'd)

Depth Bin (m)	% of Time at Depth
12–16	3.49
16–20	1.39
20–30	5.58
150–200	1.39
200–300	0.35

[1]Based on data from Gjertz et al. (2000) and Lydersen (1991)

Theses dive depths are consistent with Wathne et al. (2000), who found that ringed seals feed on shallower prey than harp seals, which make 35 percent of their dives to deeper than 100 m.

2.2.3 Sirenians

2.2.3.1 Family Trichechidae

2.2.3.1.1 *Trichechus manatus*, West Indian Manatee

The West Indian manatee is found in coastal and estuarine waters of the mid-Atlantic United States south through the waters of central Brazil (Reynolds III and Powell 2002). Manatees are primarily herbivores, feeding on plants in all parts of the water column (Alves-Stanley et al. 2010; Baugh et al. 1989; Lefebvre et al. 2000). There are occasional reports of manatees feeding on fish and invertebrate prey (Courbis and Worthy 2003; Etheridge et al. 1985; O'Shea et al. 1991). Manatees are limited to shallow water (less than 20 m), due to the light requirements of the vegetation on which they feed (Wells et al. 1999).

In order to build a representative depth distribution for manatees, data from Figure 8 in Nowacek et al. (2002) and Figure 3 in Edwards et al. (2016) were used. Nowacek at al. (2002) reported the percent time at depth for two manatees in a central Belize lagoon. The manatees were located in water that ranged from 1.5–10.5 m deep. The average time spent in portions of the water column was 80 percent in less than 3 m and 57 percent in less than 1.5 m of water. The Edwards et al. (2016) study was conducted during winters in Tampa Bay, Florida from 2002–2005, using tag data from nine manatees. In the area of the study, the water depth averages 4 m, but reaches a maximum of 27 m. Mean dive depth of these manatees was 1.09 m (SD= 0.17) with a maximum dive depth ranging from 6.0–16.2 m. Manatee diving behavior showed a diel pattern, diving deeper during the day and shallower at night (Edwards et al. 2016). The data from Nowacek et al. (2002) and Edwards et al. (2016) were averaged together to create the representative depth distribution for West Indian manatees. The depth distribution for West Indian manatees is given in Table 2-38.

Table 2-38. Percentage of Time at Depth for the West Indian Manatee[1]

Depth Bin (m)	% of Time at Depth
0–1.0	46.43
1.1–2.0	31.38
2.1–3.0	10.83
3.1–4.0	10.83
4.1–16.2	0.50

[1]Based on data from Nowacek et al. (2002) and Edwards et al. (2016)

2.2.4 Sea Turtles

2.2.4.1 Family Dermochelyidae

2.2.4.1.1 *Dermochelys coriacea*, Leatherback Sea Turtle

The leatherback turtle is globally distributed in tropical, subtropical, and warm-temperate waters throughout the year, and throughout cooler temperate waters during warmer months (James et al. 2005a; National Marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (USFWS) 1993). Adult leatherback turtles forage in temperate and subpolar regions in all oceans and migrate to tropical nesting beaches between 30° N and 20° S (Bleakney 1965; Brongersma 1972; Goff and Lien 1988; Threlfall 1978). The leatherback is typically associated with continental shelf habitats and pelagic environments. To a large extent, the oceanic distribution of leatherbacks may reflect the distribution and abundance of their favored prey, macro-planktonic soft-bodied animals such as jellyfish, salps, and pyrosomes (Wallace et al. 2013). It is suggested that leatherbacks make scouting dives while transiting as an efficient means for sampling prey density and perhaps also to feed opportunistically at these times (James et al. 2006b; Jonsen et al. 2007).

In order to build a representative depth distribution for leatherback turtles, data from Figure 2 as well as the text of Houghton et al. (2008) were used. Houghton et al. (2008) tagged 13 adult leatherback sea turtles at two sites over the course of four years. The data in Figure 2 accounts only for the percentage of dives made to each depth bin, rather than the percent of time spent in each bin. The text states the percent of dives made to less than 10 m (18.9 percent), which is considered the surface bin. This representative depth distribution was created to account for several behavioral states, including post-nesting, migration, and foraging. The mean dives in this study ranged from 32.5–69.0 m. Houghton et al. (2008) found that 99.6 percent of dives were to depths shallower than 300 m with only 0.4 percent extending to greater depths. These findings support the hypothesis that deep dives are periodically employed to survey the water column for diurnally descending gelatinous prey. The depth distribution for leatherback turtles in the AFTT Study Area is given in Table 2-39; within the HSTT Study Area, the leatherback sea turtle is encompassed within the sea turtle guild (Section 2.2.4.2.7) and is represented by the distribution found in table 2-39.

Table 2-39. Percentage of Time at Depth for the Leatherback Turtle[1]

Depth Bin (m)	% of Time at Depth
0–10	18.93
10–100	65.26
100–200	14.63
200–300	0.818
300–400	0.119
400–500	0.103
500–600	0.069
600–700	0.023
700–800	0.015
800–900	0.015
900–1,000	0.008
1,000–1,100	0.004
1,100–1,200	0
1,200–1,280	0.008

[1]Based on data from Houghton et al. (2008)

While other studies did not include usable depth distributions for leatherback turtles, they did provide additional information to categorize dive behavior. The leatherback is the deepest diving sea turtle, with a recorded maximum depth of 1,280 m (Doyle et al. 2008), though most dives are much shallower, usually less than 250 m (Hays et al. 2004; Sale et al. 2006). Fossette et al. (2007) reported that eighty percent of the leatherback's time at sea is spent diving, which is in agreement with the roughly 20 percent of time in the surface bin of the representative depth distribution. Dodge et al. (2014) found that over 90% of the time was spent in the top 100 m of the water column, and 25% of time was spent at the surface. Similarly in the Atlantic, Hays et al. (2004) determined that leatherbacks spent 71–94 percent of their diving time at depths from 70 to 110 m. Daytime foraging dives off of the Canadian Atlantic coast during summer ranged between 5.5 and 97 m with a median depth of 21.5 m (Heaslip et al. 2012). Leatherbacks dive deeper and longer in the lower latitudes versus the higher (Dodge et al. 2014; James et al. 2005a; James et al. 2005b), where they are known to dive to waters with temperatures just above freezing (James et al. 2006a; Jonsen et al. 2007). James et al. (2006b) noted that dives in higher latitudes are punctuated by longer surface intervals and much more time at the surface; individuals spend up to 50 percent of their time at or near the surface in northern foraging areas, perhaps in part to thermoregulate (i.e., bask). While transiting, leatherbacks make longer and deeper dives (Jonsen et al. 2007). During inter-nesting periods, tag data has revealed that dives are likely constrained by bathymetry adjacent to nesting sites (Hays et al. 2006; Myers and Hays 2006).

2.2.4.2 Family Cheloniidae

2.2.4.2.1 *Chelonia mydas,* Green Sea Turtle

The green turtle has a global distribution, occurring throughout tropical and, to a lesser extent, subtropical waters (Marine Turtle Specialist Group 2004) and is generally distributed between 30° N and 30° S. Green turtles are highly migratory and undertake complex movements and migrations through geographically disparate habitats, with the longest migrations occurring between foraging habitats and nesting beaches. Hatchlings swim to offshore areas where they float passively in major current systems. Juveniles leave the pelagic habitat and recruit to protected lagoons and open coastal areas that are rich in seagrass or marine algae (Bresette et al. 2006), the main prey items of green turtles. Green turtles will spend the majority of their lives in these coastal areas (Bjorndal and Bolten 1988; National Marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (USFWS) 1991). A small number of green turtles appear to remain in open ocean habitats for extended periods, perhaps never recruiting to coastal foraging sites (National marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (USFWS) 2007a; Pelletier et al. 2003). The optimal developmental habitats for late juveniles and foraging habitats for adults are warm, shallow waters (3–5 m in bottom depth) with abundant submerged aquatic vegetation and in close proximity to nearshore reefs or rocky areas (Ernst et al. 1994).

In order to build a representative depth distribution for green sea turtles, data from Figures 2 and 4 from Godley et al. (2002) and a maximum dive depth from Rice and Balazs (2008) were used. Technical limitations of the tag used in the Godley et al. (2002) study did not allow for the precise dive depth to be recorded at depths greater than 45 m. The maximum dive depth in other literature for the green turtle is 138 m, recorded from an adult female turtle migrating between nesting grounds on French Frigate Shoals in the Northwest Hawaiian Islands and foraging grounds off Laniakea, Oahu, HI (Rice and Balazs 2008). This value was used to represent the maximum depth for the dive distribution profile. The percentage of time that green turtles spent in each behavioral state (e.g., traveling vs. foraging) was not reported in the literature used for the development of the depth distribution. As a result, the time spent in each behavioral state was assumed to be equal and was averaged for a composite dive depth distribution. The depth distribution for green sea turtles is given in Table 2-40.

Table 2-40. Percentage of Time at Depth for the Green Turtle[1,2]

Depth Bin (m)	% of Time at Depth
0–5	59.23
6–10	16.98
11–15	11.68
16–20	6.78
21–25	2.61
26–30	1.39
31–35	0.73
36–40	0.26
41–45	0.06
45–138	0.28

[1]Based on data from Godley et al. (2002) and Rice and Balzacs (2008)
[2]This depth distribution is also representative of the Kemp's ridley sea turtle

While other studies did not include usable depth distributions for green turtles, they did provide additional information to categorize dive behavior. Blanco et al. (2012) reported that four turtles near Costa Rica spent 46% of their time at the surface, and while the majority of their time was in the top 10 m, the deepest dive was to 110 m. Seventy percent of the dives of migrating and foraging turtles near Brazil were to less than 30 m depth (Chambault et al. 2015). Hatase (2006) observed that green turtles dive to a maximum of 80 m in areas of the open ocean, where depths are greater than 200 m, while green turtles migrating between the northwestern and main Hawaiian Islands reached a maximum depth greater than 138 m at night (the deepest dives ever recorded for a green turtle), but only 4 m during the day (Rice and Balazs 2008). In their coastal habitat, green turtles typically make dives shallower than 30 m (Cheng et al. 2013; Godley et al. 2002; Hatase et al. 2006; Hays et al. 2000; Hochscheid et al. 1999) and often not exceeding 17.5 m (Ballorain et al. 2013; Hays et al. 2004; Rice and Balazs 2008). Green turtles are known to both forage and rest at depths of 20–50 m (Balazs 1980; Brill et al. 1995).

2.2.4.2.2 *Lepidochelys kempii,* Kemp's Ridley Sea Turtle

The Kemp's ridley has one of the smallest ranges of all marine turtle species. The distribution of the Kemp's ridley population is most concentrated in the Gulf of Mexico, with year round occurrence throughout the Gulf and southern Atlantic coasts of Florida, and seasonal occurrence along the Atlantic coast as far north as Nova Scotia, Canada (Lazell Jr. 1980; Morreale et al. 1992). Habitats frequently utilized by Kemp's ridley turtles in U.S. waters include warm-temperate to subtropical sounds, bays, estuaries, tidal passes, shipping channels, and beachfront waters where their preferred food, the blue crab, is known to exist (Landry and Costa 1999; Lutcavage and Musick 1985; Seney and Musick 2005).

While past studies have described Kemp's ridley diving behavior, results were only generalized accounts of diving behavior due to the limited capabilities of the VHF radio, sonic, and satellite telemetry equipment used in these studies. Only a couple of studies exist for which satellite tags were deployed that had the ability to record detailed time-depth information (i.e., the Renaud and Williams (1997) study in Texas and the Sasso and Witzell (2006) study in Florida). Unfortunately, the locations in which they were deployed were all extremely shallow habitats (0.3–6 m), and dive behavior was probably depth-limited, calling into question the reliability of the data. General migration and movement data indicate that Kemp's ridley turtles generally utilize waters less than 50 m deep as adults, and even shallower waters as juveniles. Byles and Plotkin (1994) noted that 18 adult females stayed in waters less than 50 m in depth during post-nesting movements in the

Gulf of Mexico after nesting in Tamulipas, Mexico. This was supported by Renaud (1995) which reported that juvenile Kemp's ridleys occupy coastal waters of less than 20 m in depth and adults remain in offshore areas of depths shallower than 50 m. Data compiled in Shaver et al. (2005) for 11 adult male in the Gulf of Mexico (Tamulipas, Mexico) showed that the majority of locations were recorded in waters of 37 m or less. Shaver and Rubio (2007) studied 28 adult female Kemp's ridley turtles and noted similar results after nesting in North Padre and Mustang Island, TX. Lastly, Seney and Landry (2008) found that 6 adult females spent 80 percent of their time in locations with waters less than 10 m deep after nesting in Galveston, TX. The submergence time of Kemp's ridley turtles varies seasonally; dives are longest during the winter (greater than 30 min), and 15 min the remainder of the year (Renaud and Williams 2005). Over a 12 hour period, Kemp's ridley turtles spend as long as 96 percent of their time submerged (Byles 1989; Gitschlag 1996; Renaud and Williams 2005; Sasso and Witzell 2006).

Due to the lack of available data on the diving behavior of the Kemp's ridley sea turtle, it will be represented by a surrogate species: the green sea turtle (Section 2.4.4.2.1). Green sea turtles inhabit similar developmental habitats in the Gulf of Mexico and Florida waters as juvenile and adult Kemp's ridley sea turtles. Furthermore, green turtles are a relatively shallow diving species, similar to the Kemp's ridley. The depth distribution for the Kemp's ridley sea turtle can be found in Table 2-40.

2.2.4.2.3 *Lepidochelys olivacea,* Olive Ridley Sea Turtle

Olive ridley sea turtles are globally distributed and have a large range in tropical and subtropical regions of the Pacific, Indian, and South Atlantic oceans; they are generally found between 40ºN and 40ºS. Most olive ridley turtles lead a primarily pelagic existence. The Pacific population migrates throughout the Pacific, from their nesting grounds in Mexico and Central America to the North Pacific (National Marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (USFWS) 2007c). The olive ridley is the most abundant sea turtle in the open ocean waters of the eastern tropical Pacific Ocean (Pitman 1990). While olive ridleys are primarily a pelagic species and are known to migrate great distances in the Pacific, there are few pelagic records of this species in the northwest Atlantic, and little is known about their migration patterns (National Marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (USFWS) 2007c). A few reports of olive ridley turtles in the North Atlantic, as far north as the Grand Banks, indicate that the species does traverse the entire Atlantic Ocean, although their occurrence north of the equator is believed rare (National Marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (USFWS) 2007c).

In order to build a representative depth distribution for olive ridley sea turtles in the AFTT Study Area, data from the text and Figure 3 in Polovina et al. (2003), the same data shown in Figure 5 in Polovina et al. (2004), as well as a maximum dive depth from Swimmer et al. (2006) were used. The depth distribution data given in both Polovina et al. studies are based on data recorded from two satellite tracked olive ridley turtles, which were tagged after being caught in commercial long-line fishing gear southwest of the Hawaiian Islands (Polovina et al. 2004; Polovina et al. 2003). The data found that the tagged olive ridley sea turtles spent about 20 percent of their time in the top meter and that 70 percent of the dives were no deeper than 50 m (Polovina et al. 2004; Polovina et al. 2003). Technical limitations of the tags used in the studies did not allow for the precise dive depth to be recorded at depths greater than 150 m (Polovina et al. 2004; Polovina et al. 2003). The maximum dive depth in other literature for the olive ridley turtle is 288 m, recorded from an adult turtle tagged after being incidentally caught in long-line fishing gear off the Pacific coast of Costa Rica (Swimmer et al. 2006). This value was used to represent the maximum depth for the dive distribution profile. The depth distribution for olive ridley sea turtles is given in Table 2-41.

Table 2-41. Percentage of Time at Depth for the Olive Ridley Turtle[1]

Depth (m)	% of Time at Depth	Depth (m)	% of Time at Depth
0–1	20.00	81–90	3.00
1–10	5.00	91–100	2.50
11–20	8.50	101–110	1.50
21–30	14.00	111–120	1.00
31–40	13.50	121–130	1.50
41–50	10.00	131–140	0.50
51–60	7.00	141–150	1.00
61–70	5.50	151–288	1.00
71–80	4.50		

[1]Based on data from Polovina et al. (2003), Polovina et al. (2004), and Swimmer et al. (2006)

While other studies did not include usable depth distributions for olive ridley sea turtles, they did provide additional information to categorize dive behavior. Olive ridley turtles can dive and feed at considerable depths (80–300 m) (Eckert 1995), although only about 5–10 percent of their time is spent at depths greater than 100 m (Eckert et al. 1986; Polovina et al. 2003). In the eastern tropical Pacific Ocean, at least 25 percent of their total dive time is spent in the permanent thermocline, located between 20–100 m (Parker et al. 2003). Olive ridleys spend considerable time at the surface basking, presumably to speed their metabolism and digestion after a deep dive (Spotila 2004). In the open ocean of the eastern Pacific, olive ridley sea turtles are often seen near flotsam, possibly feeding on associated fish and invertebrates (Pitman 1992). Olive ridleys in the shallow (less than 40 m depth) coastal waters near Oman routinely made use of the entire water column during dives (Rees et al. 2012). The average dive durations for adult females and males are reported to be 54.3 and 28.5 min, respectively [Plotkin, as cited in Lutcavage and Lutz (1997]. In a separate study by McMahon et al. (2007), olive ridleys exhibited exceptionally long dive durations (greater than two hours), allowing this species to exploit deeper benthic prey.

2.2.4.2.4 AFTT Hardshell Turtle Guild

In the AFTT Study Area, individual species densities were available for the leatherback (Section 2.2.4.1.1), loggerhead (Section 2.2.4.2.6), and Kemp's ridley (Section 2.2.4.2.2) sea turtles (Navy 2012). For green, hawksbill and olive ridley sea turtles, it was concluded that the number of sightings for these species was not sufficient to allow spatial modeling and density calculation as individual species (U.S. Department of the Navy In Prep.-b). When sightings for these three species of chelonid sea turtles were pooled with the "unidentified" sightings of all hardshell species, a density was calculated for the new group labeled the "AFTT hardshell turtle guild". Given what is known about sea turtle occurrence along the east coast of the U.S. and in the Gulf of Mexico, it is likely that the majority of the "hardshell turtle" sightings were green turtles. However, as this density number could account for green, hawksbill, or the rarer olive ridley turtle, an average depth distribution (Table 2-42) was created from the individual depth distributions for these three species. The green sea turtle depth distribution can be found in Section 2.2.4.2.1; the hawksbill sea turtle depth distribution can be found in Section 2.2.4.2.5; and the olive ridley sea turtle depth distribution can be found in Section 2.2.4.2.3. Because each species of sea turtle had a different depth range (green sea turtles diving to a maximum of 138 m, hawksbill sea turtles diving to a maximum of 91 m, and olive ridley sea turtles diving to a much deeper depth of 288 m) the bottom depth bin for hardshell turtles is very large. Each bin over 40 m for each individual species was summed, then averaged with the other species. With data combined in this way, the representative depth distribution in Table 2-42 represents the AFTT hardshell turtle guild in the family Chelonidae.

Table 2-42. Percent of Time at Depth for Hardshell Turtles in the AFTT Study Area[1]

Depth Bin (m)	% of Time at Depth
0–10	59.59
11–20	12.82
21–30	7.56
31–40	6.03
41–288	14.01

[1]Based on depth distributions for green (Table 2-40), hawksbill (Table 2-43), and olive ridley sea turtles (Table 41)

2.2.4.2.5 *Eretmochelys imbricata*, Hawksbill Sea Turtle

The hawksbill is the most tropical of the world's sea turtles, occurring in all oceans but rarely above or below 30° N and 30° S (Witzell 1983). Hawksbill nesting occurs in at least 70 countries, although much of it now at only low densities. Juveniles and adults share the same foraging areas, including tropical, nearshore waters associated with coral reefs, hard bottoms, or estuaries with mangroves (Musick and Limpus 1997). Coral reefs are optimal hawksbill habitat for juveniles, subadults, and adults (National Marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (USFWS) 1998). Hawksbills are also found around rocky outcrops and high-energy shoals—optimum sites for sponge growth, their preferred prey item—as well as mangrove-fringed bays and estuaries where coral reefs are absent (National Marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (USFWS) 2007b). While hawksbills are known to occasionally migrate large distances, possibly in the open ocean, this is the most coastal of all marine turtles. There is very little available information on hawksbills in the pelagic environments of the Atlantic and Pacific Oceans.

In order to build a representative depth distribution for hawksbill sea turtles, data from Figure 6 in Van Dam and Diez (1996) and Figure 7 in Blumenthal et al. (2009) were used. Van Dam and Diez (1996) collected data from four immature hawksbills on the foraging and resting dive behavior for resident juvenile hawksbill turtles of Mona Island, Puerto Rico. Van Dam and Diez (1996) reported foraging dives at the study site in Puerto Rico ranging from 19 to 26 min at depths of 8–10 m. Foraging dives of immature hawksbills are shorter in length, ranging from 8.6 to 14 min in duration (van Dam and Diez 1996), with a mean and maximum depth of 5 m and 20 m, respectively (Blumenthal et al. 2009; Lutcavage and Lutz 1997; van Dam and Diez 1996). A maximum dive duration of 73.5 min has been reported for a female hawksbill in the U.S. Virgin Islands (van Dam and Diez 1996). The data recorded in Blumenthal et al. (2009) represent an average of data from eighteen immature hawksbills captured in Blood Bay, Cayman Islands in 2005. Blumenthal et al. (2009) collected time and depth data that recorded for 8 days for each turtle, but the individuals' general movements were tracked for an average of 37 ± 69 days (range 11–316 days). Both datasets used to derive the depth distribution for hawksbill turtles were from juvenile turtles. Ideally, data from adult specimens are preferred since dive capacity and habitat use are influenced by body size (Schreer and Kovacs 1997). However, individuals of the same species in the same habitat can vary in body length by a factor of four (Diez and van Dam 2002; McGowan et al. 2008) and in body weight by a factor of 20 (Storch et al. 2005). To date, there have been no studies where a large number of time depth recorders have been deployed on turtles across a wide range of body sizes, enabling investigation of scaling in dive capacity and habitat use (Blumenthal et al. 2009). As a result, the data obtained from studies with juvenile turtles represents the best available data and should be interpreted as generally representative across the entire hawksbill population. The depth distribution for hawksbill sea turtles is given in table 2-43.

Table 2-43. Percentage of Time at Depth for the Hawksbill Turtle[1,2]

Depth Bin (m)	% of Time at Depth
0–2	11.31
3–10	66.25
11–20	11.49
21–30	4.68
31–40	3.59
41–50	2.04
51–91	0.65

[1]Based on data from Van Dam and Diez (1996) and Blumenthal et al. (2009)
[2]Used to create depth distributions for the AFTT hardshell turtle guild (Table 2-42) and the HSTT sea turtle guild (Table 2-46)

While other studies did not include usable depth distributions for hawksbill turtles, they did provide additional information to categorize dive behavior. In general, studies have found that hawksbills may have one of the longest routine dive times of all sea turtles. Starbird et al.(1999) reported that internesting females at Buck Island, U.S. Virgin Islands, averaged 56.1 min dives, longer than those reported in Puerto Rico by Van Dam and Diez (1996). Turtles in Eastern Tropical Pacific spent 89% of their time in waters less than 10 m deep, with the majority of time in the 5-10 m depth bin, and dove to a maximum depth of 40 m (Gaos et al. 2012). Changes in water temperature have an effect on the behavioral ecology of hawksbill turtles, with an increase in nocturnal dive duration with decreasing water temperatures during the winter (Storch et al. 2005).

2.2.4.2.6 *Caretta caretta,* Loggerhead Sea Turtle

Loggerhead turtles are widely distributed in subtropical and temperate waters (Dodd Jr. 1988). The loggerhead turtle occurs worldwide in habitats ranging from coastal estuaries to waters far beyond the continental shelf (Dodd Jr. 1988). The species may be found hundreds of miles out to sea, as well as in inshore areas such as bays, lagoons, salt marshes, creeks, ship channels, and the mouths of large rivers. Results from tagging data of juvenile loggerheads in both the eastern and western North Atlantic suggest that the location of currents and associated frontal eddies are important to the foraging ecology of the pelagic stage of this species (McClellan et al. 2007). Tagging data revealed that migratory routes may be coastal or may involve crossing deep ocean waters; an oceanic route may be taken even when a coastal route is an option (Schroeder et al. 2003). Their large heads support powerful jaws and enable them to feed on hard-shelled prey, such as whelks and conch (Erhart et al. 2003).

In order to build a representative depth distribution for loggerhead turtles in the HSTT Study Area, data from Figure 2c in Howell et al. (2010) and the text of Sakamoto et al. (1990) were used. The data recorded in Howell et al. (2010) are an average of data from fourteen adult loggerheads captured incidentally by long-line vessels in the central North Pacific Ocean during 2002–2004. The turtles were tracked for a period ranging from 51 to 578 days. Technical limitations of the tags used in the Howell et al. (2010 study did not allow for the precise dive depth to be recorded at depths greater than 150 m. The maximum dive depth in other literature for the loggerhead turtle is 233 m, recorded from an female turtle tagged off the coast of Japan (Sakamoto et al. 1990). This value was used to represent the maximum depth for the representative depth distribution below. The depth distribution for loggerhead sea turtles in the HSTT Study Area is given in Table 2-44.

Table 2-44. Percent of Time at Depth for the Loggerhead Turtle in the HSTT Study Area[1]

Depth (m)	% of Time at Depth	Depth (m)	% of Time at Depth
0–1	19.25	31–40	0.25
2 –5	43.75	41–50	0.25
6–10	13.00	51–60	0.25
11–15	9.00	61–80	0.25
16–20	9.00	81–100	0.25
21–25	3.00	101–150	0.25
26–30	1.25	150 – 233	0.25

[1]Based on Howell et al. (2010) and Sakamoto et al. (1990)

In order to build a representative depth distribution for loggerhead sea turtles in the AFTT Study Area, data from Figures 5.12 through 5.16 in Arendt et al. (2009) were used. The data recorded by Arendt et al. (2009) are an average of data from five male loggerhead turtles satellite tagged after their capture during trawl surveys in Cape Canaveral, FL. The turtles were tracked for an average of 144 days with a range of 7 to 366 days of recordings. Arendt et al. (2009) found that diving behavior of adult male loggerheads in water depths greater than 25 m was characterized by frequent, short (less than 15 min) duration dives and that the majority of time was spent in the upper 5 m of the water column. The depth distribution for loggerhead sea turtles in the AFTT Study Area is given in Table 2-45.

Table 2-45. Percentage of Time at Depth for the Loggerhead Turtle in the AFTT Study Area[1]

Depth Bin (m)	% of Time at Depth
surface	32.74
0–5	21.67
6–10	6.27
11–15	12.68
16–20	3.66
21–25	5.40
26–50	16.97
51–75	0.28
76–100	0.17
101–127	0.17

[1]Based on data from Arendt et al. (2009)

While other studies did not include usable depth distributions for loggerhead turtles, they did provide additional information to categorize dive behavior. Most studies found that, on average, loggerhead turtles spend over 90 percent of their time underwater (Byles 1988; Narazaki et al. 2006; Renaud and Carpenter 1994) and remain at depths shallower than 100 m (Hawkes et al. 2006; Houghton et al. 2002; McClellan et al. 2007; Narazaki et al. 2006; Polovina et al. 2003). Routine dive depths are typically shallower than 30 m (Hochscheid et al. 2010; Houghton et al. 2002), although dives of up to 233 m were recorded for a post-nesting female loggerhead off Japan (Sakamoto et al. 1990), and time-depth recorder (TDR)-tagged turtles near Brazil recorded occasional dives in the 200-300 m depth bin (Barcelo et al. 2013). Dives can last anywhere from 4 to 120 minutes (Bentivegna et al. 2003; Byles 1988; Dodd and Byles 2003; Renaud and Carpenter 1994; Sakamoto et al. 1990), though approximately 80 percent have a duration of about 2 minutes (Howell et al. 2010).

2.2.4.2.7 HSTT Sea Turtle Guild

This guild includes all sea turtles in Hawaiian waters including green, hawksbill, olive ridley, loggerhead and leatherback sea turtles. In the Hawaii Range Complex (HRC) region of the HSTT Study Area, three species of sea turtles are considered native: green, hawksbill, and leatherback turtles. Two other species, the loggerhead and olive ridley sea turtles, are sometimes observed in Hawaiian waters. Because it is difficult to distinguish between species during surveys, the majority of sighting records were those of “unidentified” sea turtles. The number of species-specific sighting records for individuals was not sufficient to allow for spatial modeling and density calculation. While some hawksbill and green sea turtles were observed, loggerhead, leatherback, and olive ridley were not positively identified during the collection of Navy monitoring data (Hanser et al. 2012). Although not identified during the surveys, loggerhead, leatherback, and olive ridley sea turtles do occur in Hawaiian waters and could still are among the unidentified turtle sightings. Thus, within the HRC region of the HSTT Study Area, the sea turtle guild represents hawksbill, olive ridley, green, loggerhead, and leatherback sea turtles. By considering all of these species sightings together, a more complete result can be provided for sea turtles as a guild.

The combining of sea turtle species in density calculation leads to some generalizations when a depth distribution is created for them. While some species spend the majority of time in surface waters (e.g., green, hawksbill, loggerhead), others spend more time diving below the upper 10 m (e.g., leatherback, olive ridley). Because the leatherback sea turtle is such a deep diver, this representative depth distribution for the HSTT sea turtle guild includes their maximum dive depth of 1,280 m. However, most of the other turtle species spend the majority of their time in the upper 50 m of the water column. In order to separate each individual species depth distribution from larger bins into 10 m bins, it was assumed that, within the larger bin, equal amounts of time were spent in each 10 m increment of that bin. For example, leatherbacks spent 65.26 percent of their time in an 11–100 m bin, according to Houghton et al. (2008). For the purpose of averaging this together with the other species, we have separated the 11–100 m bin into nine 10 m bins, with the leatherback spending 7.25 percent of their time in each 10 m section of that bin. In this manner, each species depth distribution was separated into 10 m bins (for depths up to 150 m, after which the bins increased in size) then averaged together and given equal weight. With data combined in this way, the representative depth distribution in Table 2-46 represents the HSTT sea turtle guild.

Table 2-46. Percentage of Time at Depth for the HSTT Sea Turtle Guild[1]

Depth (m)	% of Time at Depth
0–10	54.74
11–20	12.74
21–30	6.83
31–40	5.12
41–50	3.92
51–60	2.94
61–70	2.61
71–80	2.41
81–90	2.14
91–100	2.01

Depth (m)	% of Time at Depth
101–110	0.83
111–120	0.73
121–130	0.83
131–140	0.63
141–150	0.74
151–300	0.74
301–400	0.02
401–500	0.02
501–1280	0.01

[1]Based on depth distributions of the green (Table 2-40), hawksbill (Table 2-43), leatherback (Table 2-39), loggerhead (Table 2-44), and olive ridley sea turtles (Table 2-41)

2.3 Conclusions

The recommended static depth distributions are provided for 59 marine animal species occurring within the AFTT and HSTT Study Areas. These distributions, especially those that rely on surrogates, should be updated periodically as new data become available. Also, for most species, only a single depth distribution is presented; ideally, each species should have multiple distributions available, depending on the behavior and age/sex class of the animals being modeled, as well as the geographic location and season in which the simulation occurs. More detailed depth distribution data will permit improved realism for the scenarios being modeled.

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3. Marine Mammal Group Size Information

3.1 Introduction

Many marine mammals are known to travel and feed in groups. The NAEMO accounts for this behavior by incorporating species-specific group sizes into the modeled animal distributions, and accounting for statistical uncertainty around the group size estimate. Methods for determining group size varied between the AFTT and HSTT Study Areas, based on data availability and the recommendations of the research groups that provided density information.

Within the AFTT Study Area, group size data were collected through a comprehensive and systematic review of available visual survey data and relevant literature. Journal articles, books, technical reports, cruise reports, funding agency reports, theses, dissertations, and raw data from individual researchers, theses, and dissertations were assessed for this report. Odontocetes are more likely to occur in large groups at sea than other types of marine mammals (Acevedo-Gutierrez 2002), and are the only group for which group size data were gathered within the AFTT Study Area. Within the HSTT Study Area, visual survey data were primarily used in addition to literature, and therefore group size for some mysticetes were also included, but pinniped, sirenians, and sea turtles were not included for either Study Area.

Group size data for AFTT and HSTT include mean group size, standard deviation (SD), and a range (the minimum and maximum number of animals reported). If a range of means was given in any particular study, the maximum value was used to represent the mean as a conservative estimate of animals present. Minimum and maximum group sizes also were determined for each species. The standard deviations are incorporated in NAEMO by randomly and repetitively selecting a value from the poisson or lognormal distribution defined by the mean group size and standard deviation provided. For HSTT survey data, the Southwest Fisheries Science Center specified which species' group size followed a poisson distribution and which followed a lognormal.

3.2 Atlantic Fleet Training and Testing Study Area Group Sizes

Data from all relevant sources were pooled based on individual species occurring within the AFTT Study Area (Table 3-1). In some instances where data were lacking, data from multiple areas were combined or the geographically closest data were applied. The short- and long-beaked common dolphins (*Delphinus delphis* and *D. capensis*, respectively) only were differentiated into two specific species within the last decade. Therefore, data for both species of common dolphin were pooled, and herein both species are referred to as common dolphins (*Delphinus* spp.). Additionally, pygmy and dwarf sperm whales (*Kogia breviceps* and *K. simus*, respectively) often are indistinguishable at sea. Subsequently data for these species were combined, and the species herein are referred to as *Kogia* spp.

Table 3-1. Mean Group Size, Standard Deviation, and Ranges for Odontocetes in the Atlantic Fleet Training and Testing Study Area

Common and Scientific Names	Mean Group Size	SD	Range	References
Sperm whale *Physeter macrocephalus*	4.47	5.33	1–32	(Department of the Navy (DoN) 1995, 1998, 1999, 2000, 2001, 2002; Gero et al. 2009; Griffin 1999; Hooker 1998; National Marine Fisheries Service (NMFS) 1992b, 1995a, 1995b, 1995c, 1995d, 1995e, 1997a, 1998a, 1998b, 1998c, 1999b, 2002)
Dwarf and pygmy sperm whales *Kogia* spp.	1.52	0.82	1–4	(Department of the Navy (DoN) 1995, 1998, 1999, 2000, 2001, 2002; Griffin 1999; National Marine Fisheries Service (NMFS) 1992b, 1995a, 1995b, 1995c, 1995d, 1995e, 1997a, 1998a, 1998b, 1999b, 2002)
Atlantic spotted dolphin *Stenella frontalis*	28.44	10.42	1–121	(Department of the Navy (DoN) 1995, 1998, 1999, 2000, 2001, 2002; National Marine Fisheries Service (NMFS) 1992b, 1995a, 1995b, 1995c, 1995d, 1995e, 1997a, 1998a, 1998b, 1998c, 1999b, 2002)
Atlantic white-sided dolphin *Lagenorhynchus acutus*	15.86	17.06	1–2500	(Gowans and Whitehead 1995; Hooker et al. 1999; Kingsley and Reeves 1998; National Marine Fisheries Service (NMFS) 1995a, 1995b, 1995c, 1995d, 1995e, 1997a, 1998a, 1999a; Simard et al. 2006; Weinrich et al. 2001)
Bottlenose dolphin *Tursiops truncatus*	14.22	7.59	1–350	(Beck and Rice 2003; Department of the Navy (DoN) 1995, 1998, 1999, 2000, 2001, 2002; Gowans and Whitehead 1995; Griffin 1999; Hooker et al. 1999; Kenney 1990; National Marine Fisheries Service (NMFS) 1992b, 1995a, 1995b, 1995c, 1995d, 1995e, 1997a, 1998a, 1998b, 1999b, 2002)
Clymene dolphin *Stenella clymene*	80.00	75.54	2–165	(Department of the Navy (DoN) 1995, 1998, 1999, 2000, 2001, 2002; National Marine Fisheries Service (NMFS) 1992b, 1998b, 1999b, 2002)
Common dolphins *Delphinus* spp.	27.87	29.13	1–700	(Department of the Navy (DoN) 1995, 1998, 1999, 2000, 2001, 2002; Gowans and Whitehead 1995; Griffin 1999; Hooker et al. 1999; Kenney 1990; National Marine Fisheries Service (NMFS) 1992b, 1995a, 1995b, 1995c, 1995d, 1995e, 1997a, 1998a, 1998b, 1999b, 2002)

Table 3-1. Mean Group Size, Standard Deviation, and Ranges for Odontocetes in the Atlantic Fleet Training and Testing Study Area (Cont'd)

Common and Scientific Names	Mean Group Size	SD	Range	References
False killer whale *Pseudorca crassidens*	5.54	1.71	1–23	(Department of the Navy (DoN) 1995, 1998, 1999, 2000, 2001, 2002; National Marine Fisheries Service (NMFS) 1992b, 1995a, 1995b, 1995c, 1995d, 1995e, 1997a, 1998a, 1998b, 1999b, 2002)
Fraser's dolphin *Lagenodelphis hosei*	130.04	61.19	7–1000	(Anderson 2005; Ballance et al. 2001; Clark et al. 2012; De Vos et al. 2012; Dulau-Drouot et al. 2008; Findlay et al. 1992; Kiszka et al. 2007; Weir et al. 2008)
Killer whale *Orcinus orca*	2.50	0.71	2–3	(National Marine Fisheries Service (NMFS) 1995a, 1995b, 1995c, 1995d, 1995e, 1997a, 1998a)
Long-finned pilot whale *Globicephala melas*	10.21	1.10	1–316	(Anderson and Siegismund 1994; Bloch et al. 2003; de Stephanis et al. 2008; Gowans and Whitehead 1995; Hooker et al. 1999; Kingsley and Reeves 1998)
Melon-headed whale *Peponocephala electra*	23.26	33.85	2–400	(Gero and Whitehead 2006; Maze-Foley and Mullin 2006; Mullin et al. 2004; Watkins et al. 1997)
Pantropical spotted dolphin *Stenella attenuata*	24.55	23.41	4–145	(Department of the Navy (DoN) 1995, 1998, 1999, 2000, 2001, 2002; National Marine Fisheries Service (NMFS) 1992b, 1995a, 1995b, 1995c, 1995d, 1995e, 1997a, 1998a, 1998b, 1999b, 2002)
Pygmy killer whale *Feresa attenuata*	9.17	5.42	3–13	(Clarke and Norman 2005; National Marine Fisheries Service (NMFS) 1995a, 1995b, 1995c, 1995d, 1995e, 1997a, 1998a)
Risso's dolphin *Grampus griseus*	8.47	1.13	1–85	(Department of the Navy (DoN) 1995, 1998, 1999, 2000, 2001, 2002; Griffin 1999; National Marine Fisheries Service (NMFS) 1992b, 1995a, 1995b, 1995c, 1995d, 1995e, 1997a, 1998a, 1998b, 1999b, 2002)
Rough-toothed dolphin *Steno bredanensis*	5.50	3.54	2–20	(Department of the Navy (DoN) 1995, 1998, 1999, 2000, 2001, 2002; National Marine Fisheries Service (NMFS) 1992b, 1995a, 1995b, 1995c, 1995d, 1995e, 1997a, 1998a, 1998b, 1999b, 2002)
Short-finned pilot whale *Globicephala macrorhynchus*	15.37	4.78	1–135	(Caldwell et al. 1971; Department of the Navy (DoN) 1995, 1998, 1999, 2000, 2001, 2002; National Marine Fisheries Service (NMFS) 1992b, 1998b, 1999b, 2002; Ottensmeyer and Whitehead 2003; Payne and Heinemann 1993)

Table 3-1. Mean Group Size, Standard Deviation, and Ranges for Odontocetes in the Atlantic Fleet Training and Testing Study Area (Cont'd)

Common and Scientific Names	Mean Group Size	SD	Range	References
Spinner dolphin *Stenella longirostris*	27.60	25.84	1–225	(Department of the Navy (DoN) 1995, 1998, 1999, 2000, 2001, 2002; National Marine Fisheries Service (NMFS) 1992b, 1995a, 1995b, 1995c, 1995d, 1995e, 1997a, 1998a, 1998b, 1999b, 2002)
Striped dolphin *Stenella coeruleoalba*	45.59	37.50	1–400	(Department of the Navy (DoN) 1995, 1998, 1999, 2000, 2001, 2002; Gowans and Whitehead 1995; Griffin 1999; Hooker et al. 1999; National Marine Fisheries Service (NMFS) 1992b, 1995a, 1995b, 1995c, 1995d, 1995e, 1997a, 1998a, 1998b, 1999b, 2002)
White-beaked dolphin *Lagenorhynchus albirostris*	8.72	0.35	2–20	(Kingsley and Reeves 1998; Simard and Gowans 2008; Simard et al. 2006)
Harbor porpoise *Phocoena phocoena*	2.46	1.30	1–25	(Johnston et al. 2005; Kingsley and Reeves 1998; National Marine Fisheries Service (NMFS) 1992a, 1995a, 1995b, 1995c, 1995d, 1995e, 1997a, 1997b, 1998a, 1998c; Simard et al. 2006)
Blainville's beaked whale *Mesoplodon densirostris*	3.31	1.06	1–10	(Carrillo 2003; Johnson et al. 2004; Ritter 2001; Ritter and Brederlau 1999)
Cuvier's beaked whale *Ziphius cavirostris*	2.77	0.64	1–6	(Azzellino et al. 2008; Department of the Navy (DoN) 1995, 1998, 1999, 2000, 2001, 2002; National Marine Fisheries Service (NMFS) 1992b, 1995a, 1995b, 1995c, 1995d, 1995e, 1997a, 1998a, 1998b, 1999b, 2002)
Gervais' beaked whale *Mesoplodon europaeus*	3.50	0.05	1–10	(Carrillo 2003; Palka 2012)
Northern bottlenose whale *Hyperoodon ampullatus*	3.82	1.90	1–14	(Department of the Navy (DoN) 1995, 1998, 1999, 2000, 2001, 2002; Gowans et al. 2001; National Marine Fisheries Service (NMFS) 1992b, 1998b, 1999b, 2002; Reeves et al. 1993; Whitehead and Wimmer 2005)
Sowerby's beaked whale *Mesoplodon bidens*	2.17	1.04	1–3	(Hooker et al. 1999; National Marine Fisheries Service (NMFS) 1995a, 1995b, 1995c, 1995d, 1995e, 1997a, 1997b, 1998c; New et al. 2013; Palka 2012)
True's beaked whale *Mesoplodon mirus*	1.75	0.96	1–3	(Brereton et al. 2004; Kiszka et al. 2007; National Marine Fisheries Service (NMFS) 1995a, 1995b, 1995c, 1995d, 1995e, 1997a, 1998a; New et al. 2013; Tove 1995)

3.3 Hawaii-Southern California Training and Testing Study Area Group Sizes

3.3.1 Group Size Data

In order to create a set of group size data for marine mammals in HSTT, survey information was used. For the majority of species, group size estimates were derived from the same datasets used to develop habitat-based density models for the Central Pacific and California Current Ecosystem (Becker et al. 2016; Forney et al. 2015). For island-associated stocks in Hawaii, group size estimates were taken from peer reviewed literature and personal communications with marine mammal experts.

Data from all relevant sources were pooled based on individual species occurring at the following two components of the HSTT Study Area: the Southern California portion of the HSTT Study Area and Hawaii Range Complex (HRC). The average of all mean group sizes reported by the survey data for each species were determined, as well as standard deviations (SDs) associated with these means. Minimum and maximum group sizes also were determined for each species at each location. In some instances where data were lacking, data from multiple areas were combined or the geographically closest data were applied. For example, pygmy and dwarf sperm whales (*Kogia breviceps* and *K. simus*, respectively) often are indistinguishable at sea, so data for these species were combined, and the species herein are referred to as *Kogia* spp.

Group size information, including means, SDs, and ranges, is presented for the Southern California portion of the HSTT Study Area (Table 3-2) and HRC Study Area (Table 3-3).

Table 3-2. Mean Group Size, Standard Deviation, and Range for Cetaceans in the Southern California Portion of the HSTT Study Area

Common and Scientific Name	Mean Group Size	SD	Range	References
Minke whale *Balaenoptera acutorostrata*	1.14	0.53	1–2	(Becker et al. 2016; Forney et al. 2015)
Sei whale *Balaenoptera borealis*	1.78	1	1–5	(Becker et al. 2016; Forney et al. 2015)
Bryde's whale *Balaenoptera edeni*	2.00	0	2–2	(Becker et al. 2016; Forney et al. 2015)
Blue whale *Balaenoptera musculus*	1.68	0.90	1–5	(Becker et al. 2016; Forney et al. 2015)
Fin whale *Balaenoptera physalus*	2.23	2.99	1–29.5	(Becker et al. 2016; Forney et al. 2015)
Gray whale *Eschrichtius robustus*	2.07	1.85	1–4.2	(Becker et al. 2016; Forney et al. 2015)
Humpback whale *Megaptera novaeangliae*	1.70	0.65	1–3	(Becker et al. 2016; Forney et al. 2015)
Kogia spp.	1.37	0.46	1–3	(Becker et al. 2016; Forney et al. 2015)

Table 3-2. Mean Group Size, Standard Deviation, and Range for Cetaceans in the Southern California Portion of the HSTT Study Area (Cont'd)

Common and Scientific Name	Mean Group Size	SD	Range	References
Sperm whale *Physeter macrocephalus*	11.59	20.95	1–109.2	(Becker et al. 2016; Forney et al. 2015)
Long-beaked common dolphin *Delphinus capensis*	254.57	316.38	1–2,150	(Becker et al. 2016; Forney et al. 2015)
Short-beaked common dolphin *Delphinus delphis*	161.62	236.83	1.5–1,910	(Becker et al. 2016; Forney et al. 2015)
Pygmy killer whale *Feresa attenuata*	16.30	10.41	2–35.3	(Becker et al. 2016; Forney et al. 2015)
Short-finned pilot whale *Globicephala macrorhynchus*	37.65	16.22	26.4–61.7	(Becker et al. 2016; Forney et al. 2015)
Risso's dolphin *Grampus griseus*	18.40	21.24	1–148.5	(Becker et al. 2016; Forney et al. 2015)
Pacific white-sided dolphin *Lagenorhynchus obliquidens*	25.85	32.43	1–194.4	(Becker et al. 2016; Forney et al. 2015)
Northern right whale dolphin *Lissodelphis borealis*	13.41	12.24	2–59.9	(Becker et al. 2016; Forney et al. 2015)
Killer whale *Orcinus orca*	9.00	13.85	1–47.7	(Becker et al. 2016; Forney et al. 2015)
Bottlenose dolphin, CA/OR/WA *Tursiops truncatus*	15.88	17.16	1–90	(Becker et al. 2016; Forney et al. 2015)
Bottlenose dolphin, CA coastal stock *Tursiops truncatus*	9.10	9.80	1–50	(Becker et al. 2016; Forney et al. 2015)
Dall's porpoise *Phocoenoides dalli*	3.97	2.17	1–8.8	(Becker et al. 2016; Forney et al. 2015)
Mesoplodon beaked whale guild *Mesoplodon spp.*	2.40	1.02	1–4.5	(Becker et al. 2016; Forney et al. 2015)
Baird's beaked whale *Berardius bairdii*	8.08	4.35	5–14.5	(Becker et al. 2016; Forney et al. 2015)
Cuvier's beaked whale *Ziphius cavirostris*	2.04	1.26	1–7	(Becker et al. 2016; Forney et al. 2015)
Striped dolphin *Stenalla coeruleoalba*	55.97	64.48	1.2–348.8	(Becker et al. 2016; Forney et al. 2015)

Table 3-3. Mean Group Size, Standard Deviation, and Range for Cetaceans in the Hawaiian Region Study Area

Common and Scientific Name [Stock]	Group Size	SD	Range	References
Minke whale *Balaenoptera acutorostrata*	1.00	0	1–2	(Becker et al. 2016; Forney et al. 2015)
Sei whale *Balaenoptera borealis*	2.65	1.18	1–4.5	(Becker et al. 2016; Forney et al. 2015)
Bryde's whale *Balaenoptera edeni*	1.86	1.67	1–10.2	(Becker et al. 2016; Forney et al. 2015)
Blue whale *Balaenoptera musculus*	1.43	0.72	1–2.5	(Becker et al. 2016; Forney et al. 2015)
Fin whale *Balaenoptera physalus*	2.13	0.78	1–3.2	(Becker et al. 2016; Forney et al. 2015)
Humpback whale *Megaptera novaeangliae*	1.82	1.43	1–8	(Becker et al. 2016; Forney et al. 2015)
Pygmy sperm whale *Kogia breviceps*	1.00	0	1–3	(Becker et al. 2016; Forney et al. 2015)
Dwarf sperm whale *Kogia sima*	1.49	0.71	1–3	(Becker et al. 2016; Forney et al. 2015)
Sperm whale *Physeter macrocephalus*	8.79	9.30	1–53.8	(Becker et al. 2016; Forney et al. 2015)
Pygmy killer whale *Feresa attenuata*	16.30	10.41	2–35.3	(Becker et al. 2016; Forney et al. 2015)
Short-finned pilot whale *Globicephala macrorhynchus*	24.28	19.07	1–131.4	(Becker et al. 2016; Forney et al. 2015)
Risso's dolphin *Grampus griseus*	17.23	19.94	1–99.8	(Becker et al. 2016; Forney et al. 2015)
Fraser's dolphin *Lagenodelphis hosei*	302.98	352.88	26.3–1535	(Becker et al. 2016; Forney et al. 2015)
Killer whale *Orcinus orca*	5.71	3.88	1–17	(Becker et al. 2016; Forney et al. 2015)
False killer whale *Pseudorca crassidens* [Hawaiian Pelagic and Northwestern Hawaiian Islands]	11.18	12.13	1–52	Personal communications with Baird (Baird 2015)
False killer whale *Pseudorca crassidens* [Main Hawaiian Islands Insular]	17.88	10.26	1–41	(Becker et al. 2016; Forney et al. 2015)
Striped dolphin *Stenella coeruleoalba*	51.33	38.10	1–186.7	(Becker et al. 2016; Forney et al. 2015)
Bottlenose dolphin *Tursiops truncatus* [Oahu]	9.93	10.83	1–40	Personal communications with Baird (Baird 2015)
Bottlenose dolphin *Tursiops truncates* [4-Islands Region]	5.71	4.56	1–18	Personal communications with Baird (Baird 2015)

Table 3-3. Mean Group Size, Standard Deviation, and Range for Cetaceans in the Hawaiian Region Study Area (Cont'd)

Common and Scientific Name [Stock]	Group Size	SD	Range	References
Bottlenose dolphin *Tursiops truncatus* [Kauai and Niihau]	10.23	9.99	1–45	Personal communications with Baird (Baird 2015)
Bottlenose dolphin *Tursiops truncatus* [Hawaii Islands]	9.59	9.59	1–60	(Becker et al. 2016; Forney et al. 2015)
Bottlenose dolphin *Tursiops truncatus* [Hawaii Pelagic]	17.55	18.38	1–81	(Becker et al. 2016; Forney et al. 2015)
Rough-toothed dolphin *Steno bredanensis*	18.99	17.54	1–70	(Becker et al. 2016; Forney et al. 2015)
Longman's beaked whale *Indopacetus pacificus*	28.77	29.20	3.3–88.5	(Becker et al. 2016; Forney et al. 2015)
Blainville's beaked whale *Mesoplodon densirostris*	2.51	1.56	1–6	(Becker et al. 2016; Forney et al. 2015)
Cuvier's beaked whale *Ziphius cavirostris*	2.33	2.12	1–12.8	(Becker et al. 2016; Forney et al. 2015)
Spinner dolphin *Stenella longirostris* [Hawaii Pelagic]	134.94	219.38	1–2237	(Becker et al. 2016; Forney et al. 2015)
Spinner dolphin *Stenella longirostris* [Hawaii Island]	49.00	68.93	5–250	(Tyne et al. 2014)
Spinner dolphin *Stenella longirostris* [Kauai and Niihau]	38.70	35.10	1–185	(Baird et al. 2013)
Spinner dolphin *Stenella longirostris* [Oahu and 4-Islands Region]	38.70	35.10	1–185	(Baird et al. 2013)
Pantropical spotted dolphin *Stenella attenuata* [Hawaii Pelagic]	106.95	143.65	1–1400	(Becker et al. 2016; Forney et al. 2015)
Pantropical spotted dolphin *Stenella attenuata* [Hawaii Island]	65.40	49.60	1–350	(Baird et al. 2013)
Pantropical spotted dolphin *Stenella attenuata* [Oahu]	65.40	49.60	1–350	(Baird et al. 2013)
Pantropical spotted dolphin *Stenella attenuata* [4-Islands Region]	65.40	49.60	1–350	(Baird et al. 2013)
Melon-headed whale *Peponocephala electra* [Hawaiian Islands]	251.8	167.6	1–800	(Baird et al. 2013)
Melon-headed whale *Peponocephala electra* [Kohala Resident]	251.8	167.6	1–447	(Becker et al. 2016; Forney et al. 2015)

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